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FY14 Information Technology Discussion Document
for the Information Technology Community at Northwestern University (IT@NU)

Prepared by

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FY14 IT Discussion Document

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Executive Summary: FY14 IT Discussion Document

This is a compilation of papers put together by NUIT to share our perspectives at this stage on the information technology (IT) environment that influences us, on what we've heard through our partnerships within the community, and on the directions we're setting as result of these two. The intended audience is the IT Governance community and other campus IT and business system providers, so that we can continue to foster conversations within, and be aligned with, the larger Northwestern community.

These are times of significant change in the global and higher education information technology environment. New technological advances, new applications of technology and new expectations are emerging with unprecedented speed. These forces cannot be ignored or resisted. When they are appropriately embraced, they can improve the user experience, and opportunities can be realized for cost reduction and improved business agility.

Our ability to maximize the use of our resources, and our ability to respond to changing business needs, is greatly impacted by the way we integrate our resources to prioritize and deliver IT services. The IT governance framework will add great value by providing a forum for prioritization and alignment. So, too, will commitment to a new model of shared responsibilities rooted in partnership and dialogue. These new frameworks and relationships are designed to surface work and conversations early on, so that distracting issues are not introduced to the process only when normal needs turn urgent.

While "aligned" services does not equate to "centralized" services, current opportunities do exist for baseline services to be consolidated. There are other opportunities for alignment that involve federated services in distributed organizations, and for agreeing to development frameworks that would allow distributed solutions to more easily move to central or federated solutions at a later time. Effective partnership in this way would result in improved delivery of broadly used services, and would enable more room in the distributed units to provide more specialized services and support. This transition requires changes from all parts of the University, and while benefits and new ways of sharing work have already been realized, this process will take multiple years.

The papers collected here include an overarching Introductory section on IT trends around us and the organization of IT provisioning at Northwestern, followed by one section for each Advisory Committee, and concluding sections on Customer Service and Security. While review of the whole set is encouraged, the document has been assembled so that participants can read the overarching introductory section and any section relevant to them to get a fairly complete presentation. Each section has a one-page summary to facilitate effective use of the reader's time. A very brief overview of each section is included below.

IT Infrastructure

The management of IT infrastructure as the underpinning of all IT services can have a profound effect on the agility of the organization to introduce new system functionality and the related costs of those changes. Insufficient investments in data centers, servers and storage, and related networking infrastructure and applications can introduce significant lags in projects. A lack of enabling infrastructure, such as Identity and Access Management and Service-Oriented Architecture, can lead to complexities and sub-optimal solutions that ripple across the institution. Maintaining this infrastructure optimally and in a consolidated fashion can lead to reductions in costs and time to delivery, and increased security. Opportunities to do more are possible with the emergence of cloud computing, from both an external and internal perspective, but to realize these opportunities, investments need to occur in the enabling infrastructure. The provision of storage is being identified as an acute issue affecting the

development of new systems, requiring a review of the planning and funding model associated with storage for new projects or expanded use.

Educational Technology

The explosion of online education and the response by universities (including elite private universities) has been at the forefront of the news and dialogue within higher education. However, the dialogue on electronic learning also includes blended learning, learning management platforms, increasing the use of media in the classroom experience, flipping the classroom, and active and experiential learning. Multiple enabling technologies play a role in these discussions, and we need to continue to explore their best practices. The two most impactful variables at this time are the underlying online platform enabling these new approaches, and the support faculty and graduate students will need to advance these qualitative changes.

Research Technology

Research is also undergoing a qualitative shift in how it is being performed (more collaborative and cross-discipline, bigger datasets, utilizing simulations and modeling). This is evoking a new trend of resource consolidation in facilities, computational resources, and storage within universities (with a further eye to the cloud), which creates the need for examining how this expanding infrastructure is funded. Large-scale research data is particularly challenging. Its size makes moving and storing it qualitatively more difficult and new regulations about protection and accessibility make it more complicated.

Administrative Systems

The focus on upgrading individual enterprise systems has added great value to Northwestern. Attention needs to shift to the enabling technologies (Identity and Access Management, Service Oriented Architecture) that unlock more value from the individual systems, and provide the ability to integrate them with other campus or external systems. Opportunities for making room to do more come from improving the alignment of the development, support, and governance communities; from embracing cloud computing and improving the enabling technologies; and from reducing the institution's penchant for requiring software solutions to match existing business processes.

Focus on Service

While the trend towards Bring-Your-Own-Device strategies will change the needs for managing end users' access to online services, opportunities for reducing effort and improving consumer satisfaction can come from increasing the management of endpoint devices, offering virtual applications, and improving the integration and coordination of the delivery of IT services.

Information Security

The University's level of accountability for protecting the data we produce and store continues to increase while our level of control over that data shrinks. Appropriate responses include consolidation of data and computing resources in secure data centers, an improved Identity and Access Management ecosystem, and improved communications about using, and how to use, secured alternatives where appropriate.

We conclude with a note on our expectations for this document. This has been written as a discussion document, and it has already served, and will continue to serve, that purpose internally within NUIT. We do not expect people to offer written responses to what we have written, though if you are so moved, it will be appreciated as always. If we have overlooked something that is important to you, or you think is important to the institution, please let us know. We do hope that it will be a foundation for dialogue within the governance committees, and any feedback we receive from any part of the institution will be particularly appreciated as we prepare to write our Planning and Budget documents.

The Overarching Context

Introduction and Purpose

This is a compilation of papers put together by NUIT as a discussion document to share our perspectives on the IT environment that influences us, what we've heard through our partnerships within the community, and the general directions we're setting as result of these two.

This discussion paper is intended for the Northwestern IT community, including our partners in schools and divisions, plus our governance and advisory groups. It is organized around the recently implemented governance structure, and some familiarity with the material is assumed. We are sharing a discussion paper rather than producing a strategic plan because:

- We are just eight months into our new IT governance experience. The committees have very enthusiastic participation, and they have already proven incredibly useful as a forum for hosting discussions on fast-breaking topics such as online learning and for bringing together parts of the community for qualitatively different discussions and activities. However, the committees are still working on building the foundation of structure and knowledge. For example, activities are still occurring to extend the governance structure further into the community, to inventory services and requirements in the respective areas, and to surface work and conversations that would otherwise be unknown.
- This is the first year cross-area priorities have been requested.
- This is the first year of a new way of getting input and reflecting it back to the community, and the input/output cycles are not fully aligned.

While an IT strategic plan would be premature today, there are many areas clearly in need of attention and we need to continue to move forward. This paper is intended to keep you aware of our understanding and what actions we are taking so that we can ensure appropriate actions and further discussion and alignment. To this end, we have included discussion points at multiple spots in the document.

We are not anticipating written responses on these points or the overall compilation. Rather, we assume that these discussions will take place as needed in the governance forums already established. However, if there is something that you read that you feel is particularly off target, or leaves a gap that is important to fill, we welcome any and all input.

Structure of the Document

The paper is structured with an overarching introduction and then sections that largely correspond to the areas in the IT governance framework. The following sections cover IT Infrastructure, Educational Technology, Research Technology, Administrative Systems, Focus on Service, and Information Security. We hope that many will read the entire document, but we have compiled it in this way so that if you are time constrained and only have time to read a particular area, reading this introductory section and the relevant section should give a complete "whole".

The Broader IT Landscape

To understand the provisioning of IT for University functions, it is important to understand the broader worldwide IT environment that drives what we need to offer. Here we summarize some of the external IT developments and how they impact us in a general sense, unbounded by a defined functional area of services.

External IT Drivers

This is a time of broad and rapid change in which new possibilities created by technology are emerging across large swaths of society in ever-shortening periods of time. This is increasingly true not only for society at large, but also for the world of higher education. As examples:

- A year ago there was relatively little discussion related to Online Education in elite research universities. However, over the past year, developments in this area have been prominent in mainstream national media as well as in University presidents' and Board of Trustees' conversations around the world.
- The first iPad was released a little over two years ago, and tablet sales are now predicted to pass laptop sales in 2013.
- Google's Chrome internet browser was a distant third place in market share (10%) at the end of 2009, but is now the market leader at 45% and continuing to take market shares of both Firefox and Internet Explorer.
- Cloud computing continues to expand with an explosion of opportunities related to participating in "Software as a Service," "Infrastructure as a Service," or "Platform as a Service."

Within all of this change, a number of trends can be identified as having the most profound impact. Seven of these external IT Drivers are discussed below:

- **Big Data / Analytics**

As more services are offered online and more people and devices connect to them, the ability to amass substantial quantities of data is becoming commonplace. According to IBM, 2.5 quintillion bytes of data are created daily and 90% of the data in the world today was created within the past two years.

As these stores of data become increasingly available, the desire to turn data into information, and then into knowledge, inevitably grows along with them. According to a joint study by the IBM Institute of Business Value and MIT Sloan Management Review: "Knowing what happened and why it happened are no longer adequate. Organizations need to know what is happening now, what is likely to happen next and, what actions should be taken to get the optimal results."

The exciting possibilities offered by the size of today's data sets also give way to the compounding of infrastructural issues of storing, moving, and archiving data. Many infrastructure components that were once sufficient are now inadequate (e.g. storage, networks, etc.). Beyond the infrastructure, taking these complex sets of data and making them amenable to analysis, and then doing the analyses, are non-trivial tasks. For instance, a 2011 research report by McKinsey Global Institute predicted that by 2018, the US job market would experience a shortage of around "1.5 million managers and analysts with the know-how to use the analysis of Big Data to make effective decisions." In essence, if IT can build the analytic capabilities, the business units still need analytics talent to utilize the data.

The impact of large data and analytics on things such as research, teaching and learning outcomes, and decision making, means that this pressure will continue to expand in the future.

- **Globalization**

Globalization is a factor that is playing heavily on the expectations of the services being offered through our interconnected world and the opportunities related to how these services are offered. With the service offerings, the intended audience is becoming increasingly global in scope. Examples demonstrating this trend as it relates to Northwestern are: the Qatar campus and partnerships with international professional schools in place; the growth of Northwestern's research engagements around the globe; and even the consideration of University involvement in offering courses via Massively Open Online Courses (MOOCs). On the delivery of IT side, the location of the underlying infrastructure; the developers; or the support team for the service, mean that geographic and time differences are becoming less and less important.

This increase in globalization expands requirements for our systems by introducing potential issues related to expanded business complexity, language and cultural sensitivity, and availability of systems around calendars and time zones. On the delivery side, globalization compounds maintenance of systems and interaction with infrastructure, systems, or service support partners.

- **"Always On" / Mobility**

The evolution of laptops, smartphones, and tablets, in combination with the growth of higher-speed data and cellular networks, has fueled the ability of people to do work, or avail themselves of services, reasonably independent of time and place. This has several implications for IT services:

- As people's work habits and patterns change, and our audience becomes more distributed geographically, the expectations will be that the services should always be available. This has significant implications for the availability of maintenance windows, and by extension, the type of infrastructure that is necessary to update systems without taking them out of service.
- The explosion of different types of devices that are being used to access these services also means that designing a good user interface has become exceedingly complex. Anyone who has punched and scrolled their way through a standard web page on a smartphone or tablet, knows one size definitely does NOT fit all when it comes to web sites and device types. When this is further complicated by the functionality differences between internet browsers (Chrome, Firefox, Internet Explorer, Safari) and the various releases of each, delivering a web-based service that simply works becomes increasingly challenging.

- **Cloud computing**

Another driver of the "always on" culture is the growth of cloud computing. Organizations are able to offer highly scalable services remotely, thereby achieving economies of scale and increasing availability. Examples abound and include Gmail, Google Docs, Dropbox, Skype, Salesforce.

This greatly increases options for our community to take advantage of online services. Units all across the University, from central providers to schools and business units, are taking advantage of this technology. Like many other firms, Northwestern has begun utilizing services in such areas of storage services, software development, and education-specific applications such as admissions.

A tradeoff of the agility, functionality, ease of access, and cost advantages that comes from cloud services is a lack of control and potential increases in risk. This takes several forms:

- Control of information – information moves from being onsite and maintained by University employees to being offsite in an infrastructure which is controlled by a provider. This has implications for access, security, and management of institutional information.
- Control over IT environment – providers of systems and services are more susceptible to changing economic conditions with often more volatile business models being introduced by the providers. This has implications for stability of solutions and related business models.
- Control over how these services are utilized by the community – there is a great deal of flexibility for units providing services to constituents, or by individuals to get their University-related work done. This flexibility of being able to go out and get your own solution can result in issues related to information security, increased risks, etc.
- The ability for service providers to scale their offerings leads to ever-increasing percentages of the population using these services across a wider percentage of their activities, and this has the effect of raising expectations of usability (sophisticated user interfaces, well integrated systems, real-time transactions, always on) for all service providers.

- **Consumerization of IT**

The consumerization of IT presents itself as a challenge in multiple ways which have been referenced in the previous section, but are being presented in this section due to the impact that it has on the delivery of IT in institutions. Consumerization of IT refers to the introduction of services in the consumer market, which then demands a response by providers of enterprise infrastructure systems and services. Technology has been commoditized to the extent that consumer-oriented products are incredibly sophisticated, accessible, and easy to use, and the market in this area is driving innovation at a very rapid rate.

The result is that the locus of IT innovation has been flipped, and instead of new technologies being available first in larger institutions (business, government, and academia) and then eventually making their way to consumers, new solutions are appearing in the consumer arena and forcing their way into the larger institutions. Adoption of new devices and accommodation of new services from beyond the campus becomes the expectation and the norm with related implications for integration into enterprise services and support.

- **Community / Social Media**

Social media is a term that came into being years ago to refer to functionality that allows users to create and share their own content and directly engage one another in a community environment. Whether employed as part of an overarching social community utilizing the full range of social media; as part of more narrowly focused social-media based sites such as social networks (Facebook, LinkedIn, or Google+), standalone blogs or wikis, or crowd-sourced rating sites; or as social media elements that are incorporated into more traditional web sites, this functionality has dramatically changed the way people use the Internet. And, in the same way that the consumerization of IT has made it impossible to control which technology is used on campus, social media has made it impossible to control communications within and about the institution.

Instead, institutions have to find ways to influence and participate in these environments. Institutions are looking for ways to bring this functionality into their organizations, to provide social media within the enterprise, and others are deciphering ways to turn these services to their advantage and use them as direct feedback on their products and actions.

- **The Changing Nature of IT Organizations**

The net effect of all of these trends – more needs being addressed via online services; the shift from

developing and maintaining applications onsite to purchasing them and having them run by others offsite; raised expectations about usability, availability, and interconnected systems; faster change cycles; end users driving the portfolio of services due to the availability of consumer-oriented solutions – produces another trend: every IT organization is under incredible pressure to simultaneously change and produce at a much higher level.

Internal development timelines shorten, planning cycles are shorter and less certain, and the need for some skill sets and/or people with those skill sets shrinks while the need for others (e.g. business analyst, project management, customer relations) increases.

The less flexible the IT organization is able to be, and the less coordinated the business served by the IT organization is, the more pressure the IT organization will feel.

Higher Education

There are additional trends and drivers specific to higher education that are also important to note:

- **Redistribution of IT Provisioning**

One strength of IT delivery on campuses can be the combination of services delivered by central units and schools and departments. To the extent that this model leads to a good combination of efficiently delivered core services and, where needed, a set of specialized local systems providing services that are enhanced and aligned to the unique needs of the schools and departments, it's the best of all worlds. However, when the core systems fall short on responsiveness or efficiencies, the connections to the distributed units break; and when systems are offered locally in multiple places, inefficiencies and risk result.

In response to economic realities and integrated service offerings, the pendulum which started moving from very central organizations to very distributed environments is being revisited. Provisioning of common collaboration environments; the consolidation of data centers to provide operating efficiencies and improved security; the integration of support units, and the movement of infrastructure and services to be more coordinated in the institution are all trends that have been happening broadly in higher education.

- **Online Learning**

As referenced earlier, in the past year, online learning has exploded to a central topic of potential disruption to the higher-education field. This has resulted in a significant level of involvement and response of elite private universities that pride themselves on in-person learning. Heightened campus and societal interest has emerged in topics such as enhanced blended learning, active learning, Massively Open Online Courses (MOOCs), partnerships in delivery of enhanced courses beyond a single university, and enhanced learning analytics.

- **Research**

Research is also undergoing a qualitative shift in how it is being performed (more collaborative and cross-discipline, bigger datasets, more simulations and modeling). Running parallel to this is the trend of resource consolidation in facilities, computational resources, and storage within universities - with a further eye to the cloud. Large-scale research data is particularly challenging at this time. Its size makes moving and storing it qualitatively more difficult, and new regulations about protecting it and making it more accessible make it more complicated.

- **Cross-institution Collaboration**

Whether it is based on developing better results or more efficiently producing those outcomes, we are seeing increases in collaboration across higher-education institutions. Examples include the

growing collaborative nature of research, the collaboration of universities in providing online learning offerings, and the shared efforts in providing a shared/integrated infrastructure (all of the Internet2 service offerings for higher education).

- **Security / Regulation**

Information security continues to take on higher importance within higher-education environments. The University's level of accountability for protecting the data we produce and store is being driven up by the Big Data, increased regulations for plans and actions protecting human subject information, and increased expectations by funders of research. The importance of this increased level of accountability is compounded by the knowledge that cyber attacks on research institutions have grown, with an increased focus on gaining access to intellectual property connected to research.

Northwestern

- **Northwestern Strategic Plan**

Information Technology is fundamental to the success of Northwestern in achieving the goals set out in "Northwestern University Strategic Plan 2011: Northwestern Will." IT is a strategic enabler to each of the pillars identified in the plan.

- **Discover Creative Solutions** requires access to information, collaboration, empirical analysis or modeling, and communication of results – all of which require and are enhanced by information technology.
- **Integrate Learning and Experience** and **Connecting our Community** are both enhanced by facilitating extended reach with broader and more dynamic communities – whether for integrating the classroom learning experience with opportunities to learn beyond the campus, or for connecting with other groups such as alumni, researchers and distant teachers and learners. IT presents significant opportunities to achieve these goals.
- Finally, **Engaging the World** - whether related to globalization of education and research or to supporting Chicago-based projects - IT infrastructure and resources have played and continue to play multiple roles in accomplishing this goal.

Clearly, any of the activities presented in these discussion documents need to be aligned to the institutional mission, whether directly evident (such as many of the items in the areas of infrastructure, educational technologies, or research support) or more indirectly through administrative system support, customer service, or information security.

- **IT Governance**

The most obvious driver for IT services that is unique to Northwestern is that we are in our first year of our business-led IT governance. The comprehensive inclusion of the institution, and the business-led nature of the committees, offer new possibilities for priority setting and community discussion, and, as stated earlier, the impact of this framework has already been tangible in a number of areas and instances. However, the full effect of this will not be felt for several years. The framework needs to broaden and deepen to encompass more of the institution, it needs to become more integrated into the surrounding processes and business cycles, and we need to learn how to most effectively use this framework to identify and prioritize important IT initiatives.

This will not be without challenge. External drivers create disruption and demand change, yet our distributed organization has emerged organically over a long period of time and is not optimally positioned to respond cohesively to these changing times. Many areas of IT service – from what is offered to how it is offered - need attention. Yet we're only beginning to make a qualitative shift in

how we discuss options, set priorities, and organize ourselves. It is not possible for all of these areas to be addressed by structured decision making simultaneously.

▪ **IT Partnerships**

To leverage institutional IT resources more effectively and to gain the agility needed to meet the needs of the schools and departments, creative partnerships have to be formed to deliver new infrastructure, applications, and services. Neither the concept of the center providing all services nor schools and departments delivering independently and uniquely to their needs can match the opportunities that partnerships in delivery can produce. The shared vision to make this a priority began to emerge several years ago and has been furthered by the existence of business-led increased activity around a shared-services model for IT, primarily in the infrastructure and administrative systems areas.

The area of new partnership models in IT is not a simple undertaking and will require creativity, trust, and patience as we develop new models. The type of future delivery that can be imagined would include the move from local and ad hoc solutions to federated services across schools to centrally provided enterprise offerings. Examples abound across campus of local solutions which could have significant impact on other schools and departments. Finding creative ways to partner across organizations in ways that we haven't historically will reap large rewards for all. This topic will be expanded on in the following discussion.

A Model for the Delivery of IT Services at Northwestern

Underlying the observations in this paper is a model of shared responsibility in the delivery of IT Services at the University (IT@NU). It is a model that assumes a partnership between the central providers of IT and the distributed IT units in the schools and business units, with each type of organization playing a different role in the alignment and delivery of services.

In this model, the central providers are responsible for baseline services. These include services that are:

- part of the commonly used, pervasive IT infrastructure and its support;
- part of the provisioning of a highly reliable institutional information infrastructure;
- strategic services that require sustained commitment and development across the institution;
- necessary to ensure the provision of defined minimum levels of service, or interoperability, across campus; or
- part of a solution for a highly complex problem or a way to ensure that scarce talents are available to all departments.

On the other side of this relationship are the services provided by the distributed IT units. As long as the central IT providers are effectively providing the baseline set of services, the distributed units are able to focus on services that are:

- closely related to the unique needs of a school or department;
- best offered closely to deliver the mission of the schools and departments due to necessary knowledge and relationship requirements;
- requiring elevated or differentiated service levels from what can be offered or extended beyond the baseline offerings; or
- innovative or required in advance of broader adoption by the campus;

The key to being successful with this approach is to have partnership and dialogue, to surface work and conversations early on so there can be a discussion about how to best proceed. Having the governance and relationships are critical to have appropriate forums for discussions about priorities that include the right people as early as possible

It is important to note that having aligned services does not mean everything moves to the center. Baseline services should move to the center or get federated into central offerings to provide efficiencies, reduce risk, and free up resources for local needs. But not all services are baseline technology candidates. Sometimes alignment can simply mean that more than one school or unit shares the cost and responsibility for a service.

Alignment also occurs as a result of preparing for what might happen. Innovation should always happen with an eye towards what might happen if it succeeds and then needs to be converted to a baseline offering. Who knows about the work, when they know about it, how the product/service is designed, built, and deployed all have an impact on the difficulty involved in promoting a distributed service to a baseline offering. Though central IT providers cannot and should not always be involved in innovation, they should be involved in the dialogue. Their participation can vary in its nature and extent, from being an equal partner, to providing human resource support, or to simply observing and learning to ensure that there is a catalyst for extending opportunities as appropriate.

NUIT's Organizational Response

In response to the model articulated above, NUIT is working to change in several key ways. The following section summarizes some of these changes so that you will be aware of what we are trying to do, so you can assist us in keeping on our path, and so others can change along with us.

- **Improve Internally**

There are many successes and positives within NUIT that can be pointed to on a daily basis, but there are improvements that we can make to run more smoothly as an integrated whole and improve our connections with the rest of the institution. There is room for improvement on many levels – organizationally, operationally, interpersonally, etc. – and we are working on all of these.

- **Partnerships**

The past historic options NUIT had for addressing a validated need were either to do it all internally, or do none of it and leave it to others to handle on their own. Today, we are shifting our focus to looking for a third path via partnerships as was described in the previous sections.

Making these partnerships work will take time because most of the history in this type of participation is recent, and there will be learning on all sides: within NUIT, and within the distributed IT units. But it is important work, and the benefits will be felt by all.

- **NUIT as Hubs of Communities**

As the University's central IT organization, NUIT is involved in many activities around campus. Beyond providing services broadly across campus, we have had many bilateral working relationships with schools and departments. In some ways this has been like the hub of a wheel. These bilateral relationships dealt with cases of planning or problem solving or proofs-of-concept, with the information, knowledge, and results of the relationship shared between the unit and NUIT. With the bringing together of parties across many topic areas, our goal is to foster a different model of relationships – becoming a hub within a community.

Our role should extend to being a connector of people across the institution rather than leaving them as isolated partners with the center. Making this change will require not only NUIT to change, but it will require our partners to change as well. If the community works well together and shares work well within itself, then being a community hub can have incredible benefit and be less work.

- **Be more Transparent and Inclusive**

It's hard to foster partnerships if there is not trust, and a key to building trust is being transparent. Whether it is the work we're doing, the progress we're making on that work, what happened when something goes wrong, or where we see our shortcomings, we need to be open rather than closed.

- **Provide Leadership Content**

Working within the model described means that NUIT needs to change how we approach partnerships and communities. The model does not support a declarative approach from the center, nor does it mean passivity in defining paths forward. We need to reflect both the knowledge we have as a professional hub of the community and the recognition that the broader community has knowledge and perspective to contribute. To this end, we want to bring leadership content to each of our partnerships to help it move forward, but we also need to expect that our understanding will change as others' contributions get added to the mix. This leadership content should be grounded in our professional expertise and experience, but it should prioritize the needs of the collective schools and business units over our own organizational priorities.

Making Room to Do More in Community

In each section of this paper, we have included ideas of how we can make room to do more without simply asking for more resources. In this overarching section, there are possibilities from each side of the People-Process-Technology foundation that every IT solution is built on.

- The most obvious thread that has run through the latter sections of this introduction has been one of reducing the "noise" in the system, so the highest value topics can be identified and addressed early by the most appropriate people. This is done by broadening and focusing the conversation, and by aligning the parts, and there should be impacts on Portfolio Management and on Project Management:
 - **Coordination up to and with IT Governance** to help set portfolio priorities.
 - **Partnerships with schools and business units** to help set portfolio priorities, define and queue up work to improve the delivery of services, and agree on project scope and then stick to it.
 - **Coordination within NUIT** to make sure the organization is aligned behind new projects that are being considered, and has better project oversight processes to address projects that run into trouble.
 - **Continued examination of organization and budget structures** to better align organizations with new ways of delivering IT services as they are identified.
- At the same time that these changes in "people and process" are being addressed, there are also technology opportunities to increase our ability to deliver. The obvious examples here are the use of disruptive technologies. Rather than trying to compete with cloud-based services or consumer-oriented products, we need to adapt where possible and use them to our advantage. This will not be a wholesale adoption, and there is much work and learning to be done to mitigate the risk inherent in these solutions and to understand the trade-offs we will be comfortable making when we do use them.

- The final possibility combines all three legs – People, Process, and Technology – of the foundation. One of the biggest ways to realize savings in IT costs and improvements in service levels is to relax the requirements on fitting solutions to historic processes, pedagogical techniques, or control structures. This becomes increasingly important as the shift is made to third-party, cloud-based systems where, by definition, control over the infrastructure is in the hands of another firm. Some examples may help:
 - Whenever customization is required in a software product, time, effort, and cost is added to the implementation project. Perhaps worse, the customization must be re-applied every time the software is upgraded or enhanced by the vendor. It is often the case that customizations are the primary factor for holding back the upgrade of a software system, which may deprive the University of attractive new capabilities until the customizations can be successfully preserved. Changing a business process only needs to be done once, whereas customized software adds costs as long as that software is in place. An institutional commitment to reduce software customizations would make a big impact on the institution's ability to expand systems while keeping budgets in line.
 - Methods of instruction are rapidly changing from classroom lecture to “flipped classrooms” to synchronous distance learning to MOOCs. Insisting upon one model of instruction, or not providing faculty time to move content between delivery methods, slows down innovation in a competitive marketplace.
 - Research computing models are swinging back to central, shared facilities after 30 years of successful distributed approaches. University costs for independent computing sites, while hidden, drain resources from more important initiatives. Researchers, schools and NUIT should find new and sustainable models for meeting computing and storage needs, balancing grant charges, hidden costs, and service levels to free researchers from administrative burdens while fully supporting advanced methods.

Executive Summary: IT Infrastructure

The University “IT infrastructure” is the largely invisible complex of services and facilities supporting online resources. The IT infrastructure is run by the central IT division as a uniform service to Northwestern, targeted to deliver mainstream needs efficiently and unique requirements effectively.

Our ability to provision these services has been greatly influenced by several external trends, most of which are elaborated in the Introductory section of the discussion paper:

- The “Always on” Expectation must be designed into all levels of the infrastructure supporting it.
- “Cloud computing”, and the technologies upon which it is built, offer opportunities to reduce cost and effort, while increasing availability and agility.
- “Big Data” impacts the entire stack of IT infrastructure – storage, computing cycles, transport - in qualitative ways that challenge advances in technology.
- Changes in Research computing include a trend to consolidation powered by the demands of multidisciplinary research, the emergence of Big Data, the desire to reduce risk, and the need to realize economies of scale in compute and energy efficiencies.

The IT infrastructure can be divided into four layers: a base layer of data centers, the servers and storage devices within the centers, a communications layer that connects data centers and users, and an enabling software layer upon which applications are built, combined, and protected.

Data Centers: Maintaining data centers is expensive – power, cooling, redundancy and security. Consolidation and movement to the cloud are both reactions to this reality. Key topics are: continuing to expand the central data facilities to accommodate the consolidation of distributed and sometimes insufficient local solutions, and determining a strategy for Chicago data center futures.

Servers/Storage: The most acute issue currently facing Northwestern is the ability to provide storage efficiently and effectively. Academic and administrative storage needs, while not as large as those tied to research data, are more acute because they are increasingly tied to requests that are opportunity focused, time-bound, can come from any parts of the institution, and are outside the usual resource-planning processes. While continuing to improve forecast needs responsibly, capacity should include intentional “over-provisioning” each year to allow flexible response. Research storage is problematic because of its qualitatively bigger size, the difficulty in predicting growth trends, the complexity of the funding model, and the fact that until the last several years, research computing was distributed in local units across campus.

Communications: The big issues here are the growing need for advanced research networking, expanding wireless data and cellular coverage, and replacing the legacy phone system.

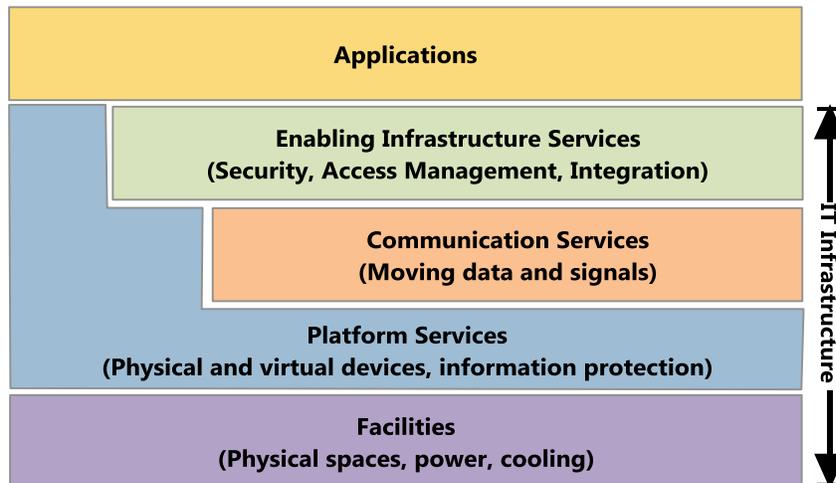
Enabling Services: Having a solid and extensive enabling services layer – e.g. Identity and Access Management, Service-Oriented Architecture - is now critical for interconnecting onsite systems, for enabling automated business processes and self-service workflows, for connecting onsite services to services in the cloud, for federating with services provided by other institutions, and for doing so in a fast and efficient manner to improve business agility. These services are overdue and in need of attention and effort at Northwestern.

Finally, whether services are provided locally or from the cloud, as more aspects of University life are enabled by online services that are expected to be “always on,” the more important Business Continuity / Disaster Recovery planning and capability becomes. Previous efforts need to be revisited to take into account the growth and impacts of new services, new technologies, and increased data.

The following discussion paper presents expanded reviews of the above items, details on current work, work considered for FY14-FY15, opportunities for reduced effort, potential challenges, and discussion questions.

IT Infrastructure

By “information technology infrastructure” we mean all communication and computing facilities and services which exist beneath and support academic and administrative functions. These are utility services that have become critical to the University’s mission. Communication services, platform services, and facilities services are the “bricks and mortar” of the IT infrastructure. On top of those services, enabling infrastructure provides standards-based software services upon which applications are built, combined, and protected.



The service philosophy for the IT infrastructure has three basic tenants:

- **Deploy reliable and maintainable services.** The IT infrastructure should be reliable, resilient and maintainable without undue business disruption. Services should be available at all times. Rigorous oversight of changes and monitoring of performance trends works to reduce the frequency of interruptions.
- **Support the University’s plans and aspirations.** The IT infrastructure should be both efficient and cost-effective, and should always be ready to absorb incremental increases in demand. This requires skilled staff, good planning intelligence, and flexible facilities.
- **Deliver mainstream needs efficiently and unique requirements effectively.** The IT infrastructure should be standards-based and “welcoming” to new applications and new devices. Services should use architectures that anticipate change and staff should have extensive industry knowledge.

External Drivers of IT Infrastructure and Impact on Northwestern

Personal Mobility

Supporting personal mobility implies effective communication from any point on campus and from anywhere with connectivity back to the University. The IT infrastructure provides both market-standard solutions and specialized functions to achieve these goals. On campus, Wi-Fi and enhanced cellular reception antenna systems support mobility. From off-campus, VPN, SSL VPN, and Eduroam are deployed to support convenient, secure access from any Internet location.

Improving Wi-Fi and cellular coverage of University buildings is a high priority. Projects are already underway to increase Wi-Fi coverage from 55% to 100% of the University’s floor space within the next three years. Recent projects introduced Wi-Fi coverage in popular outdoor locations. NUIT is working with a leading vendor to build improved campus cellular network coverage in partnership with the carriers themselves over the next three years.

Within the next three years, the University will replace its legacy telephone system with a voice application platform operating on the IP network (Voice-Over-IP or VoIP). If deployed as designed, this technology could greatly enhance faculty and staff work options due to radical changes in how telephone calls are routed and how multi-media communications could be directly incorporated.

Research Computing and Networking

For research institutions, accommodating and supporting computational research is now a primary planning concern covered in detail elsewhere. For infrastructure planners, this driver affects space, power and cooling in computing facilities and bandwidth growth for communication services. Research computing strives for higher computational capacities (and therefore, generally higher power needs) and, more recently, substantially larger data sets for analysis.

Research networks are the earliest adopters of advanced technologies to reach higher throughputs and greater utilization of shared facilities. Software-defined network architectures are now available for allocating bandwidth on demand.

The NUIT computing facilities are available for research computing applications in two locations on the Evanston campus. Proposed plans will increase the capacity for hosting research equipment by 75%. This space, plus existing power and cooling capacity, will be put to work to accommodate research storage and computing equipment as needed.

NUIT high-speed and specialized research network plans anticipate that the need to capture and move large amounts of data will drive research bandwidth requirements well above academic and administrative demand. A separate, software-defined, high-speed network may be the best approach to meeting this need.

Information Storage, Protection and Preservation (“Big Data”)

The volume of information retained by businesses is growing rapidly for at least three reasons. First, the amount of data generated by activities, sensors, and transactions is ever-growing. Our world is becoming a network of all things, and each thing is a source of data. Second, analytical systems are more powerful and, when combined with the data now available, allow new questions – which in turn require additional data structures for efficient answers. Third, the density of storage has increased and the cost of basic storage hardware has continued to drop, so that expanding storage capacity is seen as less expensive than scrupulously managing that capacity. For research activities, these factors are multiplied many-fold by increasing image resolution, increasing time sampling, and experiments that simulate physical systems at greater detail.

In addition, information is now a free-floating resource to the institution. Rather than hidden within applications, information now has value separate from any application and can be recombined to answer new questions. The means to organize this information for both discovery and secure access is a key factor to future business agility.

NUIT has invested significant time and funding into improving storage services, but as will be presented in the following discussion, much more will have to happen over the next few years. As well as increasing capacity, consistent with our primary focus being on information storage itself, we need to focus on its protection from loss. Long-term preservation of information has not been pursued as a central utility function to this time. There have been conversations involving the University Library concerning preservation and organization of repositories; however to date, no funding has resulted.

Information protection is as costly as information storage itself. Most software applications define their own working data files, or use a database system, and therefore the cost of organizing the information is a sunk cost within the software itself. Protecting that data is an additional cost outside of the application because copies of working files are created and must themselves be stored, inventoried and vaulted (sometimes) to ensure they survive a disaster and can be effectively retrieved for restoration. Strategies to manage the cost of protection will balance between level of protection and speed of recovery. For high levels of protection and rapid recovery, costs can become extreme. Ideally, all data should be classified in a way which allows appropriate protections versus the cost of recreating the data or accepting its loss.

Facility Power and Cooling Efficiency and Facility Consolidation

The electric power required to operate computing facilities has emerged as a primary concern for planning of IT infrastructure over the past seven to ten years. The cost of power can vary dramatically from region to region and now influences where companies construct new facilities. Because the power consumed by a facility combines both that used by the computing load and that used by cooling systems to remove the heat created, improvements in cooling technologies are also very important.

Many large companies (and a few large universities) have made news with projects that reduced the number of facilities from dozens to less than five worldwide. This radical consolidation saves money by concentrating efficiency efforts into controlled, managed environments. This consolidation has benefited greatly from “server virtualization,” which leverages a single physical device into from four to as many as fifty individual logical devices. This technology, more than perhaps any other, has allowed business to deploy more services from within increasingly economical facilities.

The University data center facility in Evanston has been renovated and is now the favored location for all physical hosting services – research, administrative, and academic. The Evanston facility can be expanded to over twice its current footprint in incremental phases. The Chicago facility has had a cooling upgrade and is undergoing modest remediation for acute shortages of electrical power distribution. The Chicago facility was expanded in 2007 from a network hub site to be a Business Continuity / Disaster Recovery (BC/DR) facility, but diverse use of the facility has outgrown its capacities in space, power, cooling and floor loading. We must review and formulate a new strategy for BC/DR and hosting equipment on the Chicago campus.

All modifications to the NUIT facilities pursue energy efficient designs, and in some cases projects are created solely to save energy. Improved cooling architectures are most effective, as their benefit crosses the entire facility. Replacement of aging equipment with more energy-efficient versions is an ongoing process.

Internet-Based Services (“The Cloud”)

The presence of cloud computing beyond the campus and within a campus will affect IT infrastructure delivery quite significantly in the years to come. As discussed in the previous section, this is related to functionality, affordability and agility to name a few factors in their wide adoption. This will impact the infrastructure we offer and the enabling infrastructure required.

The IT industry’s launch of cloud-based services has rightly attracted attention of many infrastructure planners as a means to move investment from physical facilities into flexible services available everywhere. All the demands described above – research computing, energy-efficiency, facility consolidation, and always-available services for mobile customers – argue for serious consideration of external solutions to save capital investment, operating expenses, and staffing. Businesses are moving away from in-house data centers and toward a mix of condominium data

center space providers and cloud-based services to meet security, flexibility, resiliency and financial goals.

Higher education, including Northwestern, will eventually find cloud solutions attractive. Already, the University has wisely elected to “outsource” certain functions to “Web-based providers” when the cost is too great to develop and sustain in-house solutions to well-defined, customer-facing applications. General cloud-based solutions move a portion of the institutional infrastructure into an abstracted layer (e.g. computational power, information storage, network bandwidth) where flexibility is desired over constrained definition. A research university must continually assess its stance and blending of solutions to attract faculty and students, ensure compliance, and optimize funding.

From an on-campus perspective, the agility and reliability inherent in these services comes from technologies such as virtualization, service-oriented architectures, data replication and synchronization, and dynamic data center provisioning. While some of these technologies are not relevant at the University’s scale, others are essential to reach levels of service flexibility that will be required in the future to affordably shape and operate a higher-education institution.

In partnership with the Weinberg College and the University Library, NUIT launched an instance of VMWare Vcloud (“NUCloud”) to create self-service, on-demand resources for use by schools and major divisions.

NUIT has been working with schools to investigate cloud-based storage options (e.g. box.net) and how those options could be used to improve productivity with adequate information security.

Spotlight Discussion Topics

The following IT infrastructure issues, which appear in context later in this document, we assemble here and propose for immediate consideration.

Acute issues

- **Expansion of administrative and academic information storage and protection.** NUIT’s ability to smoothly and predictably accommodate increased information storage needs is undermined each year by unpredictable demand and the lack of a funding model to address this demand. The majority of this demand is not from planned central projects but is coming from time-bounded or opportunistic projects that are outside of the usual resource forecasting methods. These may be projects from business units, schools, departments, or NUIT. The University should create a recurring funding model for academic and administrative storage that both relies upon planned storage projections and recognizes the reality of opportunistic projects. While calling upon all units to responsibly forecast needs, capacity should include intentional “over-provisioning” each year to allow flexible response. Examples of unplanned demands from FY12:
 - FASIS – addition of Faculty Conflict of Interest with HR Portal front-end servers;
 - SES - request for complete second QA environment of storage and servers;
 - Graduate Student Tracking System servers;
 - NUL – Increasing storage request from 16TB to 33TB in Q3 and Metalib servers;
 - NUIT – Mediasite servers, BMC Footprints servers;
 - Demand for virtual servers – The amount of storage required for new virtual servers was anticipated to be 50TB for FY12. That 50TB was consumed by non-Enterprise system requests

alone. An additional 30TB were needed by enterprise system server growth. Satisfying this total of 80TB has affected early FY13 projects negatively.

- **Correcting business concerns within Identity and Access Management.** NUIT has launched a project to identify the most important and valuable possible modifications to the current IAM system (NUValidate) with the intention of making changes for two years before having to replace the software system completely. After collecting suggested changes and pain points from focus groups, a list of possible improvements will be circulated for comment and priority setting. (See the “Administrative Systems” section.) Possible improvements:
 - Rapid provisioning of new employee credentials and access to core systems through electronic workflows;
 - Automated suspension of access rights to systems based upon changes in employee or student status – such as separation, graduation, or department change - pending the vetting of continuing needs;
 - Selective manual suspension of access rights to individual services or groups of related services.

Important issues

- **Create a business model for research data storage and protection** that will support appropriate levels of service to meet needs outside of grant funding and through grant funding. A mixture of funding sources may be appropriate for shared services, such as Vault, or Box.net, based upon the storage application. Adequate management plans for research data have become a requirement in grant proposals and responsible protection techniques will more than double the base storage cost. Researcher-owned, stand-alone solutions make less efficient use of space, power, and cooling and side step substantial hidden costs for provisioning those resources.
- **Unify application integration** and standardize access methods to University central information and services as real-time functions. By establishing standard methods, the University can encourage secure use of information, invoke business functions from portal services, mobile services, and cloud-based services, and build new applications more quickly. Through specifying its own standards for exposing information, the University can closely define requirements for vendor solutions and improve project success. By emphasizing real-time services, the University can simplify data management and security through authoritative sources (“one source of truth”) that supply information on-demand to vetted applications. Service-Oriented Architecture infrastructure is the indicated solution to this need.
- **Review business continuity plans and disaster response assumptions, establish institution-wide targets for service restoration,** and begin a multi-year plan for establishing appropriate local and remote facilities. The University’s IT disaster response posture has changed little in the past ten years, while the technology in use has been revolutionized. The mainframe is gone, but it has been replaced by hundreds of virtualized servers running on dozens of commodity server instances. Disk storage has exploded to over 500,000 GB (500TB). The University’s computing environment is now inherently self-service and open to staff, students and faculty around the clock. An extended service interruption would have proportionately greater effect than ten years ago, and a service interruption that affects Evanston might very likely affect Chicago as well. The University must take time to review its planning assumptions, response requirements, and both current and possible solutions.
- **Create a mobile application strategy and implementation plan** to enable business units and schools to efficiently deploy supportable self-service functions to personal devices. A successful strategy will encourage distributed and central development of mobile access methods that will be supportable and readily adapted to changing technologies. With a range of solutions available, the University can find common tools to save time and effort on deployment and support.

IT Infrastructure Segment - Enabling Infrastructure Services

The enabling infrastructure services are software systems that increase the efficiency and effectiveness of applications, protect University systems and information, promote personal productivity, and allow secure distributed and remote use of computing and network resources.

External developments

- Substitution of cloud-based services for on-premise services.
- Data protection, security, and preservation concerns.
- Cross-organizational collaboration.
- Integration of business processes into work flows.
- Expectation of increased productivity through mobile devices.

Northwestern themes

- Build redundant, secure, maintainable services from supported, off-the-shelf components.
- New services must be designed for a future in the cloud or serving the cloud.
- Application integration and data access improve business agility.
- Mobile devices should be effective for use with all applications.

2012 Situation Summary

- Enabling Infrastructure Services – services embedded within the networks; middleware and integration services:
 - Security - firewalls (border, data center, departmental); intrusion protection systems; virtual private network (VPN, SSL VPN); network access control (NAC); event logging and analysis.
 - Identity and access management - identity lifecycle management; directory services; web single sign-on (SSO).
 - Enterprise integration infrastructure - Service-Oriented Architecture.
 - Presentation and organization - campus portal.
- Strong-Points - aggressive security posture is proving effective; new campus portal released; campus data network is friendly to new mobile devices.
- Weak-Points - identity management system is approaching end of life; web SSO has not been widely adopted; campus portal has not been widely adopted; enterprise integration infrastructure has not been deployed; firewall rules are too complex and difficult to manage; absence of a community platform to support mobility for all applications.

Current Projects during FY13

- Theme: Build redundant, secure, maintainable services from supported, off-the-shelf components:
 - Comprehensively gather the current and future business needs of the University with respect to the current IAM system and how the University manages electronic identities – NetIDs, alumni IDs, and Wildcards – and thereby grants access to information and applications.
- Theme: New services must be designed for a future in the cloud or one serving the cloud:
 - Continue to expand the number and scope of services (portlets) available in the NUPortal. Assist enterprise system owners in working through the various issues they are concerned about in integrating their services into the NUPortal.
- Theme: Application integration and data access improve business agility:

- Work with the community to plan a strategy and gain commitment for the deployment of a Web Services environment to enable agility and reliability in our integrations of systems and information resources.
- A discussion paper has been written on this topic and is being circulated throughout the University to raise awareness and encourage the alignment of resources where appropriate.
- Theme: Mobile devices should be effective for use with all applications:
 - Engage NU community stakeholders in discussion and identification of key success factors and options for deploying administrative, community, and academic functions to mobile devices.
 - Confirm a goal of migrating Northwestern’s NU Mobile suite off of the Blackboard Mobile Central framework by August 2013 to a mobile framework that provides broader support for diverse NU mobile interests and allows for a customizable springboard.
 - Seek and obtain commitment from central and non-central data stewards for a commitment to rapid deployment of Web Services to enable the best candidate functions. Determine a solution selection process and deploy first applications.
 - A discussion paper has been written on this topic and is being circulated throughout the University to raise awareness and encourage the alignment of resources where appropriate.
 - Determine the best candidate functions for mobile deployment from academic, administrative, and student life initiatives. Include analysis and, optionally, proofs-of-concept for: (a) web mobile (HTML5) approaches, (b) native platform application authoring environments – both commercial and open source, (c) NUPortal approaches, and (d) mobile framework solutions (such as Kurogo or MWF). For each, explore development, deployment, updating, and support alternatives and the resource investments required.
 - University Relations has created a mobile view of the Northwestern website.
 - NUIT has begun to develop “reflexively designed” interfaces (the design of the interface changes in relation to the type of device accessing the application).
 - Begin campus workshops in mobile platform deployments, responsive web design, and best practices for app developers.

Initiatives and Projects Considered for FY14-FY15

- Theme: Build redundant, secure, maintainable services from supported, off-the-shelf components:
 - Deploy an IAM Web Service as an identity provider for authentication and authorization interfaces - Important for cloud-based services and future development of local and distributed applications.
 - Define and deploy high-value improvements to the IAM environment as uncovered and ranked in the FY13 fact-finding phase.
 - Complete the deployment of an institution-wide authentication and authorization infrastructure
 - Token-based two-factor authentication is needed for certain sensitive data access or high-value business functions.
 - Deploy two-factor authentication and eliminate legacy administrative logins for ERP systems in favor of NetIDs.
 - Deploy SSO into all ERP systems to enable portal deployments.
- Theme: Application integration and data access improve business agility:

- Deploy the key Service-Oriented Architecture infrastructure of a central Enterprise Service Bus (ESB) and Web Service Registry - Establish official repositories and business process support functions through highly available service architecture.
- Declare a new policy for sharing data - Evolve the ongoing approach of sharing data only when asked and by a means driven largely by the requester rather than the provider. Establish technical RFP language stating how vendors must support Web Services for interfacing to other systems for data, authentication, authorization, etc.
 - New system implementations must expose data via Web Services.
 - Systems with Web Services deployed must be interfaced to via Web Services.
 - All existing systems must launch an initiative to expose data via Web Services by the end of FY14 (August 2014).
- Theme: Mobile devices should be effective for use with all applications:
 - With community involvement, identify high-value, information access functions within central systems that can be deployed to personal devices in read-only mode. Implement those functions by the end of FY14.
 - With community involvement, identify high-value, transactional functions within central systems that can be deployed to personal devices in read/write/delete mode. Implement those functions by the end of FY15.

Making Room to Do More in Community

- Stop writing, supporting, and migrating one-off interfaces between business systems - The cost to support legacy interfaces between business systems outweighs the low cost of writing them. These functions should be moved to Web Services.
- Investigate business and technology issues pertinent to the number of MS Active Directory (AD) forests and how separate forests enable and/or hamper the efficient and effective deployment of local and global services. Perform a cost-versus-benefit analysis of alternatives that would reduce security concerns and provide more functionality.

Potential Challenges

- Is there sufficient staff expertise and bandwidth available to make a major push into deploying Web Services for data access? What priority should be assigned?
- How will two-factor authentication tokens be managed? Is the application important enough, and the deployment numbers modest enough, that high confidence can outweigh service convenience?
- A central Active Directory forest will be the means to deploy attribute-based authorization. What approach will we take to consolidating subsidiary forests or establishing trust relationships to address unique application schemas?

Discussion Questions

- How can the value of the NUPortal be enhanced through distributed authorship of portlets? What technical standards must be established?
- How should a first generation of data access Web Services be defined? Should providers propose services or consumers propose them?

IT Infrastructure Segment - Communication Services

Communication services encompass all electronic means of moving information to support the University community in pursuit of education, research, and administrative goals. Voice, data, and video applications are supported through a combination of transmission facilities.

External Developments

- Ever-increasing communication capacity.
- Ever-increasing computational power and storage capacity in personal devices.
- Global communication networks.
- Unified communication product offerings.

Northwestern Themes

- Build redundant, secure, maintainable services from supported, off-the-shelf components.
- Expand network capacity and capabilities, especially to the Internet and research networks.
- Support mobility by expanding network coverage and service capabilities.

2012 Situation Summary

- Communication services – telephony, IP data network (wired/wireless), CATV, private IP networks, satellite down-links, IPTV, video-conferencing multi-point bridges, audio-conference multi-point bridges, two-way radio:
 - Service distribution - wired distribution: twisted-pair, coaxial, fiber-optic; wireless distribution: radio, Wi-Fi, cellular; leased facilities: regional, continental, international.
 - On-campus service equipment - telephone switching; data network routing and switching; television encoding (IPTV); satellite receivers; conferencing services (audio, video); radio systems.
 - External communication connection services - telephone services: local & long-distance; data network services: commodity and research networks; television services: local CATV, entertainment, educational.
- Strong-Points - wired and wireless IP network; two-way radio system; Starlight transit point to research networks; redundant, leased inter-campus fiber ring facility; legacy telephone system has been very reliable for 25 years; two-way radio system has been recently refreshed;
- Weak-Points - legacy telephone switching system is facing end-of-life; IPTV capabilities behind market expectations; videoconferencing multi-point unit is facing end-of-life; legacy category-3 twisted-pair wiring in some locations; Wi-Fi network covers 55% of campuses; cellular reception is spotty and unreliable in many buildings; no coaxial distribution for TV in living units

Current Projects during FY13

- Theme: Build redundant, secure, maintainable services from supported, off-the-shelf components:
 - Refresh the Intrusion Prevention System (IPS) at the campus network border with a new system with higher capacity and additional features – The new system will be able to inspect all traffic flowing through the network border and give NU new features and capabilities to increase our overall security posture.
 - Deploy Network Admission Control (NAC) across the University - NAC will increase the overall security posture of the University network by requiring registration of devices and enabling different incident response options.

- Investigate options for replacing the legacy telephone system – Determine the options for replacing the legacy telephone environment with a VoIP voice communications application. Migrate the separate legacy voice mail system to a Unified Messaging solution.
- University network refresh - Rolling refresh of edge switches, distribution switches, and core routers will continue.
- Deploy a second, diverse off-campus pathway between the Chicago campus and the Internet and research/education networks – This removes a single point of failure for all off-campus network traffic.
- Replace Category-3 wiring in University buildings - Remove limitation of 10Mbps speeds on wired Ethernet circuits. New wiring will be capable of 100Mbps and 1Gbps speeds.
- Deploy IPv6 - Allow communication between University networks and external networks that are IPv6-only with the worldwide depletion of available IPv4 addresses.
- Theme: Support mobility by expanding network coverage and service capabilities:
 - Expand Wi-Fi coverage of buildings by 15% - Raise percentage of floor space covered by Wi-Fi service from 55% to 70%.
 - Refresh SSL VPN concentrators - This upgrade will remove limitations on the old hardware in terms of what software features and capabilities can be utilized.
 - Introduce eduroam services at Northwestern and for Northwestern visitors to other eduroam sites - Increase convenience and allow expanded services for visitors and traveling Northwestern community members.

Initiatives and Projects Considered for FY14-FY15

- Theme: Build redundant, secure, maintainable services from supported, off-the-shelf components:
 - Investigate a third, DR Internet connection from the Evanston campus to Milwaukee.
 - Replace legacy telephone system with Voice-Over-IP Unified Communications infrastructure - Replace the legacy telephone environment with a VoIP voice communications application.
 - Enable Network Access Control (NAC) Security Posture Assessment - Enable “security posture assessment” feature, which scans systems for vulnerabilities before allowing access.
- Anticipate future demanding research applications and support the StarLight facility:
 - Raise border router and inter-campus interfaces to 100Gbps.
 - Deploy a University research network to allow customization of services and acceleration of investment where appropriate - Software-Defined Networks based upon OpenFlow and other technologies will make research networks flexible and configurable to meet project needs. The demands of research can affect current and future applications on the general University network (e.g. video, VoIP).
- Theme: Support mobility by expanding network coverage and service capabilities:
 - Improve cellular network coverage within University buildings and improve deployed services to 4G+ - Build campus infrastructure, both outside and inside, to cover University buildings with 4G and next generation cellular services from the major carriers.
 - Expand Wi-Fi coverage of buildings by 15% - Raise percentage of floor space covered by Wi-Fi service from 70% to 85%.

Longer-Term Priorities

- Theme: Support mobility by expanding network coverage and service capabilities:
 - Refresh Wi-Fi infrastructure to next-generation technologies (300Mbps+) - Begin multi-year migration to new Wi-Fi standards that will deliver 3x to 5x current throughput.
 - Expand Wi-Fi coverage to all of both campuses - Raise percentage of floor space covered by Wi-Fi service from 85% to 100%.

Making Room to Do More in Community

- Rationalize videoconferencing applications - Reduce the number of videoconferencing solutions and support a core for collaboration versus distance education.
- Rationalize multipoint videoconferencing service need and solution - Determine if cloud-based services can replace the need for on-campus MCU and IPVCR functions.
- Identify requirements to satisfy access and security concerns for BYOD model of end-user equipment - Hand-held, tablet, and laptop devices should predominate in coming years.
- Limit deployment of physical telephone sets in the next telephony environment - Telephone sets are costly, require repair, and require costs to move. Reducing the number of physical telephone sets can save costs, time and manpower.

Potential Challenges

- Replacing the legacy telephone system raises mobility questions. Should self-relocation of station equipment be permitted? Should computer-based softphone applications be allowed? Should mobile “smartphone” applications for VoIP be allowed? Most of these questions are tied to E911 location information concerns. What are the risks versus benefits of allowing increased mobility while compromising on E911 function? What compromise approaches can be considered?

Discussion Questions

- What priorities would the community assign to supporting mobility for academic versus administrative functions?
- As Wi-Fi capability increases over time, how should the University deploy communications services in new buildings? Could Wi-Fi be the primary communication network with wired connections only where research applications require them?

IT Infrastructure Segment - Platform Services

Platform Services refers to the physical and virtual servers, storage, and related servers that deliver our applications and services. NUIT operates two sites where these systems and storage are located – one on each campus.

- Evanston: 2020 Ridge Ave – University data center; primary computing and information storage site; research equipment hosting site; secondary inter-campus linkage point.
- Chicago: Abbott Hall – Network convergence point; primary inter-campus linkage point; primary linkage point for all Internet connectivity; legacy telephone system; DR/BC data center.

External Developments

- Continuously available services – no downtime.
- Business continuity through regional disasters.
- Data protection, security, and preservation concerns.
- Low cost of hardware versus high cost of software to operate, monitor, and manage it.

- Substitution of cloud-based services for on-premise services.

Northwestern Themes

- Rationalize and normalize funding for information storage, protection, and preservation.
- Build redundant, secure, maintainable services from supported, off-the-shelf components.
- Leverage the two on-campus facilities to enhance service continuity and resiliency.
- Improve intelligence gathering for capacity modeling and management projections.
- Support facility consolidation through virtualization and flexible floor plans.

2012 Situation Summary

- Platform services – Virtualized capacity hosting (processing, storage); data protection (replication, tape storage, tape vaulting):
 - Computing and information management facilities - University data center (Evanston); DR/BC data center (Chicago)
- Strong-Points - virtualized capacity for processing and storage is very effective.
- Weak-Points - current tape backup technology is approaching practical capacity limits; insufficient information storage capacity.

Current Projects during FY13

- Theme: Build redundant, secure, maintainable services from supported, off-the-shelf components:
 - Load balancer infrastructure refresh - Revisit marketplace for traffic management services to enhance inter-site transparency.
 - Refresh VM cluster physical hardware and operating software - Annual rolling upgrade of a portion of the VM cluster physical servers along with a global upgrade to VMWare ESX 5.
 - Data Center network refresh - Raise basic internal network capacity; improve inter-site transparency; adopt new software-defined network and hypervisor-aware network features.
- Theme: Leverage on-campus facilities to enhance service continuity and resiliency.
- Create a business-driven IT Disaster Response (DR) planning process:
 - Engage the Business Continuity Planning (BCP) manager in a review of business functions.
 - Determine Restore Time Objective (RTO) and Restore Point Objective (RPO) for each business function.
 - Translate business objectives into technical architectures and budgetary estimates.
 - Data center HIPAA/HITECH compliance ISSP/P procedures notebook - Complete process begun in FY12 to reach compliant standing with adequate and targeted documentation
- Theme: Support facility consolidation through virtualization and flexible floor plans:
 - Expand capacity of NUCloud – Provides capacity to assist with data center consolidation projects.

Initiatives and Projects Considered for FY14-FY15

- Theme: Rationalize and normalize annual funding for information storage, protection, and preservation:
 - Create an annual funding model for academic and administrative storage that will support appropriate levels of demand each fiscal year. Define a process to discover annual storage needs to smooth deployments.

- Create a funding model for research storage that will support appropriate levels of service to meet needs outside of grant funding and through grant funding.
- In partnership with the University Library, deploy information preservation services to begin long-term retention of important University records and digital assets.
- Deploy storage quotas tools - Users have asked for accurate monitoring of disk utilization under their control. Existing SNMP-based storage monitoring is not appropriate for file systems and storage on the Isilon (returns inaccurate measurement of disk space utilization).
- Deploy cloud-based storage for target applications - Use cloud storage for file sharing and research data archiving.
- Theme: Build redundant, secure, maintainable services from supported, off-the-shelf components:
 - Make necessary near-term improvements to existing data protection and DR resources.
 - Upgrade the tape backup system to higher density with more tape drives.
 - Expand significantly the disaster-response readiness storage in the Chicago data center, including data protection for NUCloud.
- Theme: Support facility consolidation through virtualization and flexible floor plans:
 - Prepare for cloud-based applications - Build necessary software infrastructure (Web Services, NUcloud) to enable migration of applications to cloud providers. Build administrative tools to qualify providers. Test and document performance of providers for certain applications (e.g. development, testing). Compile knowledge of the direction of these alternatives.
 - Continue expansion of NUCloud
- Theme: Improve intelligence-gathering for capacity modeling and management projections:
 - Improve ability to project resource requirements across years based on historical trending and improved customer input.
 - Cloud computing guidance: Internal vs. External - Develop & establish criteria that provide guidance and recommendations on best use of cloud resources (e.g., under what conditions might we recommend external cloud over internal?), to include specific solutions (e.g., Box, Amazon Web Services, etc.).

Longer-Term Priorities

- Theme: Rationalize and normalize annual funding for information storage, protection, and preservation:
 - Evaluate Information Management software to optimize placement of data on storage tiers.
- Theme: Build redundant, secure, maintainable services from supported, off-the-shelf components:
 - Improve application monitoring and trouble reporting systems through: easier/more intuitive tools for acknowledging and silencing Nagios notifications; more intuitive interface for scheduling downtimes; and more granularity with regards to Nagios notifications, i.e. different notification and escalation schemes for business hours versus evenings/weekends.
- Theme: Leverage the four on-campus facilities to enhance service continuity and resiliency:
 - Evolve cross-data center redundancy and application resiliency using active-active architectures.
 - Establish FISMA-compliant processing capabilities within the University data center - Research grants and projects are required to provide and certify computing services that are FISMA-compliant. This can be achieved by leveraging the standards implemented under HIPAA.

- Theme: Improve intelligence-gathering for capacity modeling and management projections:
 - Security Event Incident Management (SEIM) - Develop in-house or acquire a commercial solution, a service that provides for the monitoring & manipulation of data collected from multiple & disparate devices for purposes of network performance, security & incident management (prevention & resolution).

Making Room to Do More in Community

- Use external cloud solutions where appropriate. Offsetting the increase in resource requirements that cloud solutions can create in enabling infrastructure and related human resources, they can also reduce the requirements for provisioning on campus solutions, whether that is for server hardware, storage, application infrastructure or human resources.
- Expand use of NUCloud and other cooperative server and storage solutions with schools and departments.
- End Enterprise Laser Printing done by CI Service Operations so IT resources can be better utilized - Options being reviewed include departments purchasing their own equipment.

Potential Challenges

- All infrastructures must be maintained. There is a shrinking amount of time free to perform important infrastructure maintenance given: (a) the number of software systems and hardware systems to be maintained, (b) 7x24 service expectations, and (c) overseas campuses. Investment in N+1 infrastructures may be needed at higher levels of the technology stack to minimize disruptions and their duration; however, disruptions can never be eliminated.
- NUIT responsiveness and agility depend upon sufficient resources, including storage, power, space, and staff time. A shortage in any one resource can hold up one or many projects. The University has made substantial investments in some of these resource dimensions, but others can - and have - become constraints.
- Increasing staff turnover of in-demand facility and system engineers.

Discussion Questions

- How can the institution best provision for the expanding storage requirements for administrative, teaching and learning and research needs? What are the optimal strategies for funding to meet these increased requirements?
- Can data be classified in ways that allow different protection strategies so that some data is replicated to disk, versus tape, versus no backup?

IT Infrastructure Segment - Facilities Services

NUIT operates over two-hundred spaces on both campuses that provide network and computing services to the University. Four facilities are the primary aggregation points for IT services.

- Evanston:
 - Leverone Hall – Network convergence point; primary inter-campus linkage point; legacy telephone system.
 - 2020 Ridge Ave – University data center; primary computing and information storage site; research equipment hosting site; secondary inter-campus linkage point.

- Chicago
 - Abbott Hall – Network convergence point; primary inter-campus linkage point; primary linkage point for all Internet connectivity; legacy telephone system; equipment hosting site; DR/BC data center.
 - Rubloff Building – Secondary inter-campus linkage point; secondary linkage point for all Internet connectivity.

Five other managed spaces are: Tech LG87 (research equipment hosting), and four network distribution sites at Crown Center, Rogers House, Tech Institute, and the Lurie building. Over two-hundred additional spaces in all buildings contain local electronics and battery backup power.

External Developments

- Continuously available services – no downtime.
- Business continuity through regional disasters.
- Scrutiny of energy consumption in facilities.
- Substitution of cloud-based services for on-premise services.

Northwestern Themes

- Build redundant, secure, maintainable services from supported, off-the-shelf components.
- Leverage the four on-campus facilities to enhance service continuity and resiliency.
- Support facility consolidation through virtualization and flexible floor plans.

2012 Situation Summary

- Facility services – Physical equipment hosting
 - Communication facilities - core switching facilities (Evanston, Chicago); hub routing and wired distribution rooms; edge switching and wired distribution closets; Wi-Fi controllers and access points; antenna sites: radio, cellular; satellite receivers; VPN concentrators
 - Computing and information management facilities - University data center (Evanston); DR/BC data center (Chicago); research cluster site (Evanston Tech building)
- Strong-Points - excellent primary data center with capacity for expansion; data centers are HIPAA-HITECH compliant; all network hub and edge locations have 2-hours of UPS power; site diversity for off-campus network connectivity
- Weak-Points - secondary data center needs power system overhaul; hub locations are facing cooling issues as routing & switching is refreshed

Current Projects during FY13

- Theme: Build redundant, secure, maintainable services from supported, off-the-shelf components:
 - Retrofit network routing/hub sites for future power and cooling requirements – New generations of networking equipment generate more heat
- Theme: Leverage the four on-campus facilities to enhance service continuity and resiliency:
 - Remediate Chicago facility electrical environment:
 - Remediate Chicago data center AC branch circuit loads - Improve reliability and agility by changing the AC power distribution wiring for Chicago data center administrative racks.
 - Retrofit Chicago power distribution for DC plant to true A/B for Starlight - Replace the Chicago DC plant A and B batteries. Add additional wiring and correct distribution structure to deliver true A/B where needed in Starlight.

- Replace aged UPS batteries - Batteries have reached or exceeded useful life. Some batteries are failing.
- Theme: Support facility consolidation through virtualization and flexible floor plans:
 - Expand Evanston data center into room 171; add 8 research racks; move SOC into office space - Provides important research rack space.

Initiatives and Projects Considered for FY14-FY15

- Theme: Build redundant, secure, maintainable services from supported, off-the-shelf components:
 - Re-evaluate current BC/DR facilities and examine alternatives given changes in technology and partnership opportunities:
 - Investigate a DR site outside Central Time zone at another higher-education institution, commercial facility, or cloud-based solution.
 - Investigate a DR site separate from the current Chicago facility for processing, storage, and network functions on the Chicago campus.
 - Investigate a third, DR Internet connection from the Evanston campus to Milwaukee.
- Theme: Leverage the four on-campus facilities to enhance service continuity and resiliency:
 - Determine the future need for the current Chicago NUIT hub facility and, if necessary, invest in refurbishment.
 - Replace all electrical wiring in the Chicago data center – Needs for greater AC power capacity and future re-purposing of floor space recovered from the legacy telephone system will require that electrical distribution be “up sized” and enlarged.
 - Replace Chicago UPS plant – Aging equipment and the need for greater AC power capacity will drive replacement of the original UPS plant.
- Theme: Support facility consolidation through virtualization and flexible floor plans:
 - Expand LG87 by two racks through use of rear-door heat exchangers
 - Enlarge the Evanston data center by removing the entire wall between 171-172; add 8 research racks; etc - Positions NUIT to install 40 additional racks of equipment at incremental costs in following fiscal years.

Longer-Term Priorities

- Theme: Leverage the four on-campus facilities to enhance service continuity and resiliency:
 - Establish FISMA-compliant processing capabilities within the University data center - Research grants and projects are required to provide and certify computing services that are FISMA-compliant. This can be achieved by leveraging the standards implemented under HIPAA.
 - Electronic locking solutions for cabinets; from simple proximity card readers to sophisticated biometric locking devices - Eventual compliance issue>

Making Room to Do More in Community

- NUIT and Chicago campus units – including affiliate partners – should investigate possible partnerships for secure computing and information storage facilities. Consolidation of these facilities could be advantageous due to the high cost of compliance with regulations common to all healthcare organizations.
- Within the IT@NU community, investigate how consolidation of computer room spaces could save funds, improve reliability, and reduce staff effort for departments, schools and divisions. Create case studies to illustrate the actual effects of space consolidation and server virtualization.

Potential Challenges

- All infrastructures must be maintained. There is a shrinking amount of time free to perform important infrastructure maintenance given: (a) the number of software systems and hardware systems to be maintained, (b) 7x24 service expectations, and (c) overseas campuses. Investment in N+1 infrastructures may be needed at higher levels of the technology stack to minimize disruptions and their duration; however, disruptions can never be eliminated.
- NUIT responsiveness and agility depend upon sufficient resources, including storage, power, space, and staff time. A shortage in any one resource can hold up one or many projects. The University has made substantial investments in some of these resource dimensions, but others can - and have - become constraints.
- Increasing staff turnover of in-demand facility and system engineers.

Discussion Questions

- What is the long term strategy related to the future of the Abbot Hall computing facility? What options exist, if any, to the current requirement for this to be a disaster recovery site?
- How will Chicago campus secure facility planning be coordinated between other partners?

Executive Summary: Educational Technology

Change is the operative word for educational technology at Northwestern in 2012. MOOCs, online courses for credit, blending learning enhancements, flipping the classroom, active learning spaces, course nuggets, expanding the learning environment “above the classroom” via social software, looking to evolve our learning management environment, experimentation with tablet-enabled learning, and the increased interest in learning analytics will all be areas of interest. All of these are topics of discussion that reflect the following key drivers cited in *2012 NMC Horizon Report: Higher Education Edition*:

- People expect to be able to work, learn, and study whenever and wherever they want to.
- The technologies we use are increasingly cloud-based and our notions of IT support are [becoming increasingly] decentralized.
- The world of work is increasingly collaborative, driving changes in the way student projects are structured.
- The abundance of resources and relationships made easily accessible via the Internet is increasingly challenging us to revisit our roles as educators.
- Education paradigms are shifting to include online learning, hybrid learning, and collaborative models.
- There is a new emphasis in the classroom on more challenge-based and active learning.

The other part of change in educational technology at Northwestern in 2012 is the creation of the Educational Technology Advisory Committee (ETAC). This committee has been very active and has provided a forum for engaging across the campus that has been met with enthusiasm by the participants from the Schools.

The combination of great change, the new ETAC forum, and that few entities are already organized strategically, leads to an approach where community collaboration around new initiatives presents an opportunity for school based leadership in determining future educational technology tools, and therefore increased opportunities for partnership alignments and awareness of activity across campus.

There will be experimentation with a variety of purely online learning options – SCS, 2U, and possibly others. Experimentation will also be happening in campus-based learning: blended learning, flipping the classroom, active learning. Experimentation will also be happening with the technological threads that run through these different modes: new learning management tools, the use of video to record whole courses or smaller “nuggets,” or to connect people synchronously; using tablets and wireless connectivity to enable different forms of interaction; exploring the use of eTextbooks; evaluating the opportunities presented by learning analytics and changing the arrangement of the classroom and the technology within it.

One key to these changes is the learning management software platform. A review is currently commencing to understand what changes are required for our future platform. If the mode of learning is changing, the online services on which that learning depends must enable those new modes and the capabilities discussed above.

At the same time, a great deal of content and effort is already in place. Whether it is changing the LMS or learning new tools or whole new approaches to teaching, providing support to faculty will be critical during these changes.

The following discussion paper presents expanded reviews of the above items, details on current work, work considered for FY14-FY15, opportunities for reduced effort, potential challenges, and discussion questions.

Educational Technology

This section offers a tour of “educational technologies” developments and opportunities that are vying for attention at Northwestern as necessary capabilities for supporting the University’s ambitions as a world leader in undergraduate and graduate education.

The educational technologies discussed in this paper represent a wide set of potential capabilities for the University. They include technologies such as: a campus-wide software platform that provides better learning management services for courses and programs; new capabilities for improving instructional decisions, advising guidance, and outcomes predictions from the use of learning analytics; much better capabilities for managing, delivering and re-using rich media (video, audio, simulations, images, and more) and learning content for instructional goals; adaptable, convenient and ubiquitous use (when desired) of video collaboration applications to enable work across the campuses and the world; and social media services that support both structured and informal developments of the campus learning community.

The worldwide landscape for support of teaching and learning is becoming increasingly influenced by the growing number of cloud-based services and by the reach today of “good-enough” IP networks and cellular data networks to almost all locations of society. As a result, it’s now more often the rule than the exception that people throughout the advanced countries and the emerging countries of the world look to email, messaging or social media applications as key methods for sharing information, doing business, becoming educated, and participating in society. As a result, the market for higher education is becoming global and online.

When we turn attention to the technology trends of the last few years within university communities, there are some changes in the customary roles of technical leadership at play. Research universities have been the leaders in the use of networks and many of the most-advanced and new computing applications for most of the last 30 years. However, the recent dynamics of cloud services, the rise of mobile applications, the use of social media platforms, and the strategic use of digital video have generally been exploited in more dramatic fashion OUTSIDE the campus community during the last few years, than is the case ON campus. An argument can be made that this situation is now changing in university organizations, and there is some recent evidence to support this. But, the exact pace and characteristics of the adoption of these new technology trends – so important in the off-campus world – is proceeding somewhat more slowly on campus, partly for reasons of institutional policy that is deeply rooted in local control and local management of IT infrastructure, data, and services.

Background: Status of Work in this Area at Northwestern

- Blackboard Learn has been the campus-wide production Course Management System (CMS) at Northwestern for 13+ years. Approximately 7,000 course sites are now hosted each year.
- The Northwestern instance of Blackboard Learn has been extended with several Building Blocks: Google Apps for Education (Bboogle); Turnitin (plagiarism checker); Primo (the NU Library’s federated access for digital resources); Xythos (file services); and Mediasite video delivery (December 2012). NU’s production version of Learn is about a year behind Blackboard’s latest release of the CMS.
- The NU Classroom Committee has developed 115 electronic classrooms and auditoriums for Registrar scheduling (Evanston). Another 35 classrooms under management contracts by NUIT (Evanston and Chicago).

- NU's "homegrown" online education efforts are booming, under the direction of the School for Continuing Studies (SCS). The Provost is in discussion with external partners regarding new commitments by NU for online education (2U, Coursera).
- NU blended learning efforts, which help enable advances such as flipping the classroom, are growing and successful. Some NU faculty members are experimenting with Massive Open Online Courses (MOOC's) and with next generation Learning Management Systems (LMS) platforms in the cloud. Our faculty's appetite for this experimentation seems to be rapidly growing.
- NU has completed investments in room-based videoconferencing in approximately three dozen locations (classrooms and conference rooms) across campuses. Six of these rooms, managed by NUIT, are available for common scheduling for the entire community. Activities in smaller classrooms are benefitting from experiments with commodity video services such as Skype.

Background: External Trends

The EDUCAUSE Learning Initiative and the New Media Consortium (NMC) publish an annual report as part of the NMC Horizon Project, spotlighting key trends in teaching and learning and the relation of these trends to important emerging technologies. The *2012 NMC Horizon Report: Higher Education Edition* identified the following trends as key drivers for the 5-year horizon of 2012-2017:

- People expect to be able to work, learn, and study whenever and wherever they want to.
- The technologies we use are increasingly cloud-based, and our notions of IT support are [becoming increasingly] decentralized.
- The world of work is increasingly collaborative, driving changes in the way student projects are structured.
- The abundance of resources and relationships made easily accessible via the Internet is increasingly challenging us to revisit our roles as educators.
- Education paradigms are shifting to include online learning, hybrid learning and collaborative models.
- There is a new emphasis in the classroom on more challenge-based and active learning.

In the course management space, dramatic changes are underway:

- The dominant CMS vendor, Blackboard, has lost its once monopoly-like market share (71% of the LMS market five years ago), first to Moodle and Desire2Learn, but more recently to a new crop of "next generation" learning management systems that seem born to support blended learning activities and the community aspects of online education.
- The Sakai effort, founded by a consortium of research universities in 2004 as a higher-education (and open-source) challenge to Blackboard, seems to have run aground as critical university partners have withdrawn this year from the slackening development effort.
- Massive Open Online Courses (MOOC's), using experimental social learning platforms developed at computer science departments at leading universities, are enrolling tens of thousands (even hundreds of thousands) of students from around the globe. The MOOC's have, as of yet, an uncertain financial sustainability model, but they are dramatic expressions of the readiness of many members of modern society to seek education opportunities online and in experimental forms of learning communities.
- The new generation of learning management systems and MOOC's varieties are student-centered, rather than focused upon services for "silo" course sites.

- The most interesting new learning platforms support adaptive and customized learning modalities, are usually cloud-based, and are hardwired with learning analytics engines and dashboards.
- Many of the most innovative new LMS efforts are funded by venture capital investment and staffed with talented software developer teams with backgrounds distinct from higher-ed.
- Some of Northwestern's peers are forming new alliances for sharing best-practices with these new LMS platforms, or for providing steering advice to next-generation LMS vendors.

Leading Trends and Driving Issues at Northwestern for Teaching and Learning

The University's interests and efforts in online education are expanding on multiple fronts. Online degree programs led by the School of Continuing Studies (in partnership with other NU schools) are successful, and demands are coming from external professional communities for expansion of these programs. The University continues to progress towards an agreement to be a charter member of the Semester Online (SON) undergraduate effort, along with the vendor 2U and other highly ranked universities. Individual NU faculty members are experimenting with offering their courses in MOOC's. The Provost's Office is leading discussions regarding the University's possible role within the Coursera MOOC effort, and Northwestern's role in other online education efforts is now a part of campus discourse.

- What additional capacities on campus (production facilities, human resources, etc.) are necessary for success in new online learning initiatives?
- Can the learning content that is developed for entirely online efforts be effectively re-used for on-campus courses? If so, what are the standards or management systems that need to be in place in order to most effectively re-use learning content in multiple teaching environments?
- What are the support staff needs for distinguishing Northwestern's work in online efforts? How will the providers of support, including the schools, the Searle Center, the School of Continuing Studies and NUIT's Academic & Research Technologies unit, offer and coordinate services.

The fast-developing field of learning analytics is drawing increased interest from educators, administrators, and LMS developers. Capabilities are beginning to be provided by learning analytic engines for support of real-time instructional decisions (to students), learning progress maps (for instructors), advising data and curriculum design analytics (for departments).

- What are the options for most effective adoption of learning analytics at Northwestern? Should the University develop learning analytics primarily as an in-house effort with our current business analytics talents? Or is it more effective to expect learning analytics to be "baked" into the future LMS systems of choice at Northwestern for online education? Or do we need to experiment with both paths?
- Are there high costs and risks for early development and early commitments in this area?
- Peers such as Michigan are now providing research funds for select faculty to support development of prototype learning analytic services. What can we learn from such efforts?

An increasing number of NU faculty are interested in augmenting blended learning and flipping-the-classroom models – reserving classroom time for engagement with higher order learning goals, spirited discussions, small-team project activities, or more advanced lecture topics.

- What are the characteristics of an electronic learning environment that best support the University's ambitions for blended learning and flipping-the-classroom? Many faculty members report that Northwestern's CMS (Blackboard Learn) is not as flexible as they need for work in this area.
- What capacities are needed to help NU faculty prepare the course nuggets (course casting clips, video clips), problem sets, or other learning content required for these learning models?
- What role might the developing ebook market (and the recent formation of university consortia for etext-bundling) have in helping to advance Northwestern's interests in flipping-the-classroom?

Active Learning classrooms are technology enhanced classrooms designed to support a radical turn away from lecture-based science courses to combinations of project-based instruction, peer-oriented learning, and small-team work on assignments and simulations. The active learning curriculum model is designed to force interactions among teams of students working on short, discipline-oriented problems and challenges. All research to date of active learning classrooms points to measureable gains in learning outcome for these classroom/curriculum models when adopted for large-enrollment science and engineering courses.

- Active learning classrooms typically require a significant reinvestment in classroom renovation and technology upgrades for the classroom space. And these classroom investments must be accompanied by even larger-scale commitments by instructors to curriculum redesign and adoption of new teaching methods. What is the scale of the effort necessary to get started in the use of active learning classrooms?
- What classroom designs best support flipping-the-classroom? Should these designs be reflected in the upcoming Kresge Hall renovations (FY2014-FY2015)?
- In what areas is the active learning model of interest at Northwestern beyond large enrollment STEM (science, technology, engineering and mathematics) courses?
- How does this development relate, if at all, to the flipping-the-classroom interests emerging in various departments at Northwestern? (see above item) What technologies allow early experimentation along the path to active learning? How can we achieve increased WiFi service in classrooms and better support of mobile devices to facilitate this experimentation?

Enterprise social media platforms in higher education encourage development of community culture and social knowledge. These platforms can advance both work-focused and learning-focused collaborations, whether structured or spontaneous, within a relatively private and secure environment compared to open-to-all-the-world social systems such as FaceBook and Twitter. The philosophy of these systems being applied to education is that you first seek to build an appropriate community for learning, including alumni, mentors, faculty, students, etc. and then build the environment and content to facilitate this happening.

- Should there be a campus-wide social media platform at the University, available to all schools and communities? Or, instead, are interoperability standards for social media platforms sufficient to bridge separate community platform efforts among different schools?
- Many "new generation" LMS's have social media features integrated throughout the vertical stack of the system's functionality. Is this the best target for development of social community services for the University?

Current and Upcoming Committed Projects (FY13)

Work in Online Education

- Support the Provost's decisions regarding new online education initiatives by Northwestern. This may involve efforts during FY13 for targeted faculty support of Coursera (MOOC) course development.
- In concert with the Searle Center for Teaching Excellence, identify best practices for use of course nuggets, simulations, and learning objects in online education.

Work in Blended Learning and Flipping the Classroom

- With guidance from the Educational Technologies Advisory Committee (ETAC), begin an investigation of alternative Learning Management Systems (LMS) options that would best serve the University's growing interests in blended learning and online education. Support the campus-wide review committee that is being formed for this work. As one effort in this investigation, conduct a LoudCloud (alternative LMS) pilot with Medill and SCS for two NU courses during spring quarter 2013. Participate in the recently formed NGATE Alliance of universities (currently Michigan, Indiana, Wisconsin, Northwestern) in shared investigation and assessment of next generation electronic learning environments and learning content repositories.
- Build out a base set of campus-wide Mediasite infrastructure, services, and workflows for video capture, video content management, and live video webcasting. The first school partners for this expanded Mediasite effort are Feinberg and Kellogg. Next requests for the campus-wide Mediasite services are coming from SESP and Law. Prepare for adoption in subsequent years from other units of the University. Put Mediasite to use for live NU webcast productions. Begin discussions within the NU Classroom Committee of paths for adoption of Mediasite services in selected Registrar-controlled smart classrooms in Evanston during the next three years.
- With guidance from the ETAC governance committee, begin investigations of other educational technology issues of highest priority for campus efforts in teaching and learning. Top priorities for study identified by ETAC include: (1) Learning Analytics, (2) Digital Access Management systems for support of teaching, learning, and scholarship; (3) Active Learning Classroom designs that address Northwestern curriculum redesign goals; and (4) expansion of Course Nuggets production capacity for NU faculty. Discussions with ETAC will provide the best steering for the pace and depth of these additional studies, many of which should commence in FY13, but will probably require deeper and longer study than can be entirely accomplished in 2013.

Work in New Classrooms

- Develop and refine new classroom design(s) for seminar classrooms with the NU Classroom Committee and the Searle Center for Teaching Excellence. Pending new funding, renovate and upgrade additional Evanston classrooms during FY2013 and FY2014, in time for the closing of Kresge Hall in summer 2014 for a two-year period of renovations.
- Collaborate with the Classroom Committee and biological sciences faculty on Tech classroom improvements that will promote active learning in undergraduate biology courses.
- Prepare information related to videoconference improvements in Evanston that will better support the broadcast of life science seminars across the campuses, as well as to desktops, laptops and mobile devices.

Improvements in Faculty Support

- Work with the schools, School of Continuing Studies and the Searle Center to define a cohesive support environment for online education and educational technology support, especially related to anticipated increases in demand related to all the online activity.

- Expand production support for faculty experimentation with course nuggets, course casting and learning objects. There have been repeated inquiries from NU schools about recommendations for a cross-platform, easy-to-use authoring product for these developments. Selection and campus support of these tools would meet increasingly urgent interests from Northwestern faculty.
- Expand workshops and support for faculty considering using technology in classrooms and for MOOC's and other online education efforts.

Recommendations for Near Term Priorities (FY14-FY15)

Work in Online Education

- Support the Provost's decisions regarding new online education initiatives by Northwestern. This may involve support during FY14 for additional faculty participation in Coursera or other institutionally sponsored MOOC developments.
- With the guidance of ETAC, study and make recommendations for next steps regarding use of learning analytics at the University.

Work in Blended Learning and Flipping-the-Classroom

- Plan and support pilot(s), alternative LMS pilots. The featured, alternative LMS pilot(s) for Northwestern will be recommended by ETAC. Under the guidance of the LMS Review group of ETAC, perform assessments of these early LMS pilots. Use the assessments to promote community discussion of best opportunities for blended learning and online education.
- Develop a strong and creative "alliance of the willing" among the NU schools, NUIT, The Searle Center for Teaching Excellence, and select development partners for the development of best practices in online education and blended learning.
- Continue investigations and discussions with the NGATE alliance of universities regarding a next-generation LMS and learning objects repository.
- Expand the production capacity at the University for the creation of Course Nuggets by NU faculty, for support of blended learning, for online education and for NU's commitments to participation in MOOC's. Work with ETAC, the Provost Office and General Counsel regarding Creative Commons (or similar) licensing practices for this learning content.
- Finish the build out of Mediasite services and workflows for the campus. Prepare for Mediasite adoption by other schools at the University. Distribute and support new Mediasite tools for faculty-authored course nuggets and course casts.

Work in New Classrooms

- Support the investigation of active learning classroom designs for large-class STEM courses at Northwestern.
- Advance a funding model to the Classroom Committee (and in consultation with ETAC) for equipping select Registrar-controlled classrooms with Mediasite recording hardware.
- Expand videoconferencing capabilities in selected NU classrooms, initially with advocates from the NU life sciences.
- Expand WiFi coverage to additional NU classrooms, in concert with the Undergraduate Budget Priorities Committee and the NU Classroom Committee.
- Promote partnerships to share best practices and lessons learned in bringing these new pedagogical techniques into the classroom.

Improvements in Faculty Support

- In concert with the Searle Center, expand NUIT's training efforts (workshops, seminars, communications) in topics of blended learning, active learning, best practice opportunities for mobile devices and use of classroom WiFi.
- Maintain the "heritage" Blackboard Learn CMS as a production LMS during FY2014, but stop offering locally developed extensions and customizations that require high levels of staff support. Instead, align NUIT staff efforts towards support of experimentation by faculty in new pilots and investigations of next generation LMS systems. These new efforts should be targeted for best support of blended learning and online education goals of the University.
- Chart the technical path and faculty training effort that could be required in FY2015, or later, to migrate Blackboard Learn course site content to an alternative LMS.

New Educational Technologies

- Deploy a replacement set of media encoding and publishing services during FY14 for the deprecated NU Mediaspace system for video. The new services might be an interim solution until long-range commitments are identified (with guidance from ETAC) for a comprehensive digital access management (DAM) for campus-wide support of teaching and learning.
- With guidance from ETAC, study the advances that are beginning to appear in the market for interoperable Learning Object Repositories, which enable learning content to be efficiently managed and re-used across LMS platforms, MOOC's, and other teaching platforms.
- Support tablet and smartphone efforts that are important for classroom and curriculum goals. Expand support for coordinated (and managed) mobile developments for teaching and learning, academic applications and community development. (See the "IT Infrastructure" discussion paper.)
- With the guidance of ETAC, monitor and participate, where appropriate and able, in higher education alliances that are advancing ebook and ejournal licensing efforts, which will be advantageous to our students. Track the outcomes and consequences of the current ebook format wars.

Possibilities for Longer-Term Priorities

- Study the business model (including increased agility for upgrades and scaling) for moving relevant portions of Northwestern's learning management environment to the cloud.
- Expand production and training support for faculty participation with alternative LMS's, targeting faculty members who are making commitments to teach in a blended learning mode or in an online education mode.
- Expand Northwestern's use and adoption of learning analytics. Some of our peer universities are making first, big steps in this area.
- Identify and acquire (or, as a last resort, build) a comprehensive DAM or repository that will provide back-end support for teaching and learning content, including the management of learning objects for multiple LMS's.
- Provide support (with the Classroom Committee, ETAC, NU biological sciences program, and (possibly) the Howard Hughes Medical Foundation) to build Active Learning Classrooms for STEM classes at Northwestern. Active Learning classroom redesign efforts must be closely coordinated with academic departments' redesign of curriculum practices, typically modeled on SCALE-UP TEAL projects and upon Active Learning principles.

Making Room to Do More in Community

- Retire the Depot file management system by the end of FY13. Work with the Collaboration Services team to migrate remaining users (primarily NU administration units) off of Depot and onto SharePoint or similar.
- Rationalize multipoint videoconferencing service needs and solutions. Determine if cloud-based services can replace the need for on-campus MCU and IPVCR functions. On a related track, articulate a strategy related to consumer versus enterprise video conferencing software. To this end, find and support Skype integration efforts into NUIT videoconference services, including classrooms.
- Work with vendors to enable Vidyo as a back-end, scalable videoconference engine for Lync. Reduce NUIT's campus-facing support efforts for Vidyo as a standalone video application.

Potential Challenges

For at least the next few years, it will be important for NU to experiment, conduct pilot efforts, and expand services in the LMS space. This experimentation and process of discovery will require more resources (financial and staff skills) than currently available to this service area. This experimentation and process of discovery will require the willingness to allow for some failures along the way to success.

As the incumbent NU CMS for over a dozen years and with a corporate history that is not entirely admirable to higher education, Blackboard suffers from low regard among parts of the NU community. This is to be expected. But this might leave NU with a particular blind spot to some indications of innovation and scalability in Blackboard's new developments and university alliances, such as xpLor.

The emergence of new generation LMS's in the cloud allow for easier experimentation by NU faculty in new teaching efforts. A downside to this rapidly emerging environment is the possible isolation of learning content and LMS practices to unmanaged, off-campus platforms.

Discussion Questions

- With the developments in the online education, blended learning, and related technologies, infrastructure, and learning techniques, what are the support relationships needed between the schools and central providers to more effectively support faculty and graduate students with these developing requirements and increased demands?
- What is the appropriate timeline for a review of the learning management environment?

Executive Summary: Research Technology

Over the past decade, several macro-level changes have begun to transform the way in which research has traditionally been conducted:

Traditional	Emerging
Methods of theory supported by experiments	Methods that integrate theory and experiments with modeling and simulation
Discipline centric	Interdisciplinary
Small, local investigative groups	Very large collaborations, including large scale multi-institutional international projects
Dependence on local facilities	Use of highly distributed resources
Modest-sized data sets	Extremely large data sets
Separate and often local resources	Shared central and national resources

These trends combine to create challenges for how the University delivers services to support research within the new parameters in order to attract the best faculty and students, increase grant funding, enhance research instruction, and form communities of researchers and practitioners.

New pressures require new responses and business models. Key topics from the discussion paper are:

- **Shared services** - In response to campus and funding agency drivers, there is increased interest in developing and leveraging common research infrastructure. Security of information, efficiencies related to capital infrastructure costs (e.g. facilities, compute, network and storage) and ongoing operating costs (e.g. energy), opportunities to more broadly leverage specialized and expensive facilities such as clustered and grid computing, and requirements to more securely store and preserve information are all contributing to this move to more consolidated research infrastructure. As this happens, new investments to maintain faculty interest and support are needed, and support and funding models need to be devised for services that are now shared.
- **Research data storage** – As well as the dramatic increase in requirements due to Big Data, the protection, archiving, and accessibility of data is coming under increased pressure from federal funding organizations and information security requirements. How the University provides solutions will directly impact the competitiveness of research proposals being submitted for funding.
- **Computation Science Technologies** – The requirements for computational computing are increasing. Our campus solution, Quest, is performing to the maximum and requires ongoing investment to meet the need and stay current. Although very large infrastructures for research are available and of interest for high-end computing for Northwestern, their applicability is limited (highly parallelized applications). Other alternative facilities for clouds, also have limited applicability at this time due to tool sets available or associate business models. However, recognition exists that a range of options are necessary for this area in the future.
- **Visualization** – Exploring and presenting subject data in advanced ways is an area that holds great promise for research, outreach, and education efforts. We have the opportunity and need to expand current successful efforts beyond the communities currently exploiting these opportunities.
- **Developing a high performance network infrastructure.** The sharing of massive amounts of data is becoming commonplace in several research areas, including high-energy physics and genomics. Requirements are exceeding the capabilities of the campus production network.

The following discussion paper presents expanded reviews of these areas, details on current work, work considered for FY14-FY15, opportunities for reduced effort, potential challenges, and discussion topics.

Research Technology

Conducting high quality leading edge research is one of the fundamental missions of Northwestern University, and its major achievements are being increasingly recognized through discovery breakthroughs, funding levels (\$500M/yr since FY10) and key publications. To continue this progress the University must continue building a research cyberinfrastructure foundation upon which new discoveries can flourish and that enables its research community to increasingly compete for federal funding.

Over the past decade, several macro-level changes have begun to transform the way in which research has traditionally been conducted:

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These trends are creating challenges for how the University delivers services to support research within these new parameters. For example, in 2010 nearly two-thirds of all science and engineering publications were co-authored with 24% of these papers being written as a result of international collaborations. This tremendous growth in collaborative science, since 1988, is, in part, a direct response to the complexity of the challenges being addressed that offer very high reward. To further complicate matters, researchers across the world are collecting data from an array of increasingly diverse sources and instruments including sequencers, sensors, and many large-scale specialized research instruments that are capable of generating several terabytes of data with each acquisition – and the rate of instrument implementation and acquisitions is increasing.

In response to the above trends, we have witnessed steady growth in the development and provisioning of shared and central research cyberinfrastructure within research universities in the United States, Europe and Asia. Northwestern is not an exception to this. Years ago support for research computing, as well as the resources themselves, was handled entirely in a decentralized manner. Over the past five years we've begun to see a shift towards the center with the development of new data center space for hosting of research equipment, the development of new centrally offered computing (Quest) and storage facilities (Vault), and investments in specialized staff to support users of these services.

In addition to facilitating the granting of ever-more advanced research projects, these centralized research cyberinfrastructure facilities are proving to be important drivers for new interdisciplinary research and for attracting top-notch students and researchers, while taking into consideration fiscal responsibility and security (for example, through reduction of expertise, equipment, power, cooling, space renovation needs necessary for localized support, and implementation of federal regulations for the storage of sensitive identifiable data (e.g. HIPAA)). These facilities are not just targeting high-end science users, either. High performance computing, data intensive research, and visualization have permeated a broad range of disciplines encompassing not just traditional computational domains, such as the physical sciences and engineering, but also medical research, the social sciences, performing arts, life sciences, and the humanities.

Northwestern must begin to address several pressure areas in support of the University's core research agenda. The remainder of this section outlines current and future priorities, trends, and challenges in these key research cyberinfrastructure thrust areas:

- **Data Storage and Management:** Systems, services, and policies for the effective sharing, analysis, and security of research data.
- **Computational Science Technologies:** Identifying computing capabilities necessary for accelerating research and developing a sustainable funding model to ensure on-campus computing resources remain modern and attractive for faculty investment.
- **Visualization:** Broadening the impact of visualization services for development of highly informative visual representations of researchers' real, simulated, or conceptual data, which are used to aid in the successful exploration of complex science and its dissemination to colleagues, students, sponsors, and the general public.
- **Hosting of Research Cyberinfrastructure:** Management and growth of centralized data center space for the effective hosting of research equipment.
- **Networking:** Increasing the capacity and capability of our networks to address data-intensive science and collaboration needs.
- **Integrated Architecture for Research Cyberinfrastructure:** Leveraging an increasingly diverse set of research cyberinfrastructure resources and services for addressing research problems.
- **Teaching, Education, Outreach, and Engagement:** Professional staff with highly specialized skills will be in increasing demand to help our researchers and students navigate and apply the best technologies to their research.

Data Storage and Management

Researchers are collecting data from a diverse array of sources and instruments, including sequencers and sensors that are capable of generating several terabytes of data with each acquisition, overloading commodity networking bandwidth and facing new challenges with increased regulations for data access, preservation, and security. As federal agencies have taken greater interest in both research data confidentiality and sharing of funded research results, those agencies have begun to require data stewardship plans with emphasis on protection from data loss and inadvertent data release (i.e., compliance with Federal Information Security Management Act or FISMA), while providing for appropriate information distribution.

External Trends

- Increased expectations by regulators and funding agencies for institutional-wide implementation of policies and infrastructure that ensure the security of regulated data. (*i.e., FISMA-compliant processes and storage*).
- Government funding agencies like NSF and NIH are requiring researchers to follow agency guidelines when planning data management.
- Cloud storage services, such as Box.net, provide ease of use and scalability for limited types of sharing data not easily replicated with localized solutions.
- New variable-cost cloud data archiving options (e.g., Glacier) provide exceptionally low cost services for storing archived data, but charge for access and transfer.

Current and Upcoming Committed Projects

- **Evaluation of Box.net for use as a collaborative platform for sharing research data.** In support of the NUIT Infrastructure Governance Committee initiative, review cloud based storage solutions (box.net, Google drive, etc.) for supporting some types of collaborative sharing of data. If funded,

one of these cloud solutions might be able to replace in part (or in whole) the Vault Collaborative service.

- **More fully understand the diverse storage and data management needs of Northwestern to inform service development.** In concert with the University Library and Weinberg College, support the University Library eScience steering group in the development, distribution and analysis of a campus-wide survey on research data storage and management patterns and solutions.
- **Implementation of GlobusOnline** to facilitate high performance file transfer across national labs, supercomputing centers and other campuses. GlobusOnline is being used by several leading national computing centers and research universities to enable efficient transfer of large data between computing, storage, and visualization facilities.
- **Plan for ensuring the security of research data** on all studies involving human subjects which requires the development of new governance, organization, policy, workflow, and technology solutions.

Near-Term Priorities (FY14-FY15)

- **Provision new secure storage services for handling regulated data.** Increasing collaboration between Feinberg and north campus researchers is an important element of the University's research plan. We estimate that Northwestern may have over 1 petabyte of regulated data residing on researcher desktops, laptops, mobile devices, USB drives, and servers. However regulated data needs are not entirely resident within the Feinberg School. Both the Weinberg College and the School of Communication have needs for secure storage services. Along with the Feinberg School, the Weinberg College, the McCormick School, and the School of Communication, identify secure storage services for holding sensitive data.
- **Adopt and implement a security framework** that will support FISMA compliance.
- **Re-evaluate Vault**, alongside the Feinberg School, the Kellogg School, and the Weinberg College, for fit with handling targeted large data tasks. Researchers have articulated the need for desktop/server mounted storage for storing of data by a group or lab.
- **In concert with the University Library, Office for Research, the Weinberg College, and other administrative units, Identify and develop a model for preservation, archiving, and curation/preservation services** in support of federally mandated requirements for research data lifecycle management.

Longer-Term Priorities

- **Identify relational database services** and techniques to store and mine data for large-scale scientific research.
- **Identify and provide support for truly Big Data science research.** Increasingly 'Big Data' science activities are occurring exclusively in the cloud as a result of the expense for moving and storage of that data locally to a university.

Making Room to Do More in Community

- **Migrate Vault Collaborative** tasks to the cloud (e.g., box.net) for some research data sharing needs.

Discussion Points and Challenges

- **Costs for long term archiving and preservation depend upon what and how long data is kept.** What should the University's policy be on data retention? Can we generalize data retention characteristics based on the funding entity or by discipline?
- **Should Northwestern develop a policy for publishing research data at the end of a project?** Publishing data on finished research projects has long been the responsibility of the individual

Principal Investigator. These methods often have included sharing upon request or through limited access ftp or web servers. Should Northwestern develop a more concerted effort for publicly making its research data available?

- **Research Data Management Planning Services.** What types of data management planning consulting services would be helpful? How do researchers from various disciplines need to be differently supported?
- **Are we correctly targeting the range of data services needed by researchers?** We have identified needs for support of collaboration, large data, and regulated data. What other services should be under consideration? What types of access patterns are emerging?
- **Creation of a business model for research data storage and protection.** Research data storage, its protection, archiving, and accessibility are coming under increased scrutiny by federal funding organizations. How the University provides solutions may directly impact the competitiveness of research proposals being submitted for funding. What does a sustainable business model for storage look like? Should the University provide some amount of storage for gratis? What cost underwriting should occur, if any, for researchers needing to purchase storage from a University sponsored solution? Should centralization occur? What University policies should exist with regards to ownership and responsibility of research data given external pressures?

Computational Science Technologies

The adoption of advanced computing and analysis infrastructure as indispensable tools in virtually every discipline fundamentally changes the way research problems are being approached. Rapid increases in raw computing power and storage capabilities enable new research inquiries, even in disciplines where computation played essentially no role a decade ago. In science and engineering, computer simulations are now the third pillar of research next to theory and experiment, and the use of new types of multi-core processors and systems, data intensive computing, and Big Data science will enable studies of problems in their full complexity and realism.

External Trends

- Increasing density of commodity compute nodes is providing for more cost-effective scaling of resources, but has challenges in programmability and code optimization.
- New computing technologies, such as GPGPU & Hadoop offer the potential to positively impact research application areas by introducing new efficiencies that reduce the mean time to result and may enable more complex research inquiries to occur.
- Large scale (TFlops, PFlops) federated resources have become available through national facilities (XSEDE, the Open Science Grid, Mira, BlueWaters) and provide platforms for scaling computational models. However, they require significant computational science expertise to be leveraged effectively.
- Cloud computing is providing opportunities for scientists to leverage computing capability for increasingly data-intensive tasks, but usability and cost advantage is not applicable to all research applications.

Current and Upcoming Committed Projects

- **Expansion of Quest.** Quest is being expanded with approximately 1,000 commodity compute cores and 15 General-Purpose Graphics Processing Unit (GPGPU) nodes with National Science Foundation (NSF) Major Research Instrumentation (MRI) funding obtained jointly with Professor Vicky Kalogera. Additionally, Quest will be expanded to include new Hadoop capabilities for analyzing CMS data being generated by the Large Hadron Collider.

- **Broaden use of emerging HPC technologies** (e.g., GPGPU, Shared Memory Processing, Large Memory, and Intel MIC) for scientific investigation by NU research groups. Leveraging national resources, we are beginning to enable new research through exposure to emerging HPC technologies.
- **Develop support methodologies that enables researchers to leverage leadership-class national Terascale and Petascale computing facilities** to further drive discovery and innovation. Conduct at least six consulting projects with NU research groups to assess moving research computing practices to national facilities such as XSEDE, BlueWaters, and Mira.
- **Develop new Full-Access practices for Quest** that motivate Northwestern faculty to co-fund central research computing services. Assist in developing grant proposals that, if funded, would increase Full-Access participation in central research computing services.
- **Continue the support and growth of the Social Science Computing Cluster (SSCC).** In concert with Kellogg and WCAS, support the research and teaching activities of social sciences faculty and their graduate students through expansion of SSCC services and capabilities.

Near-Term Priorities (FY14-FY15)

- **Sustainable funding and funding model for Quest.** Keeping the Quest research computing facility up to date not only facilitates the granting of ever-more advanced research projects and attracts Principal Investigator investment, it also helps the University cement its reputation as a world-class research institution.
- **Evaluate Quest for support of analyzing regulated data.** As mentioned previously, Northwestern is predicted to hold over 1 petabyte of regulated data. Quest, by its design, was not aligned to the analysis of regulated data. Services such as two-factor authentication, auditing, and enforcement require evaluation.
- **Evaluate participation in federated research resource networks such as XSEDE and the Open Science Grid.** National research resource facilities are increasingly providing methods that enable researchers to expand out of localized resources to larger national facilities. Often times this benefit requires the sharing of local resources as part of the federated grid. However, these platforms might provide a means of incrementally expanding resources for targeted projects and applications.
- **Investigate access to cloud computing** as the means to evaluate technology trends and ease pressures on computing demand.
- **Increase Network capacity to Quest to dedicated 10Gb** in support of large data flow and analysis. (See the “IT Infrastructure” discussion paper.)
- **Expand support for life science research areas.** Life sciences researchers remain an underrepresented group of users of central computing resources. In concert with the Feinberg School, the Weinberg College, and the McCormick School, identify the technology and consulting solutions necessary to broaden support of life science research.

Longer-Term Priorities

- **Developing metrics for success.** Judging the success of Quest in supporting research and scholarship should be based upon its applicability, acceptance, competitive advantages, and return on the University’s investment.

Making Room to Do More in Community

- **Distributing Support.** Supporting specific research environments by central staff does not scale efficiently. For new application areas, central staff must exert a considerable amount of effort to understand not only the specific application, but also the usage patterns of the user and enough of the science to help verify correct function. However, given the broad support that the research

computing team provides, becoming expert in any single research application is nearly impossible. In certain situations, support for discipline-specific application environments can occur more effectively through collaboration with local support staff in the co-design of research application environments. Local support staff, with the backing of NUIT Research Computing, can then assume a primary role in training and support of users.

Discussion Points and Challenges

- **Funding, technology, and support model for computing.** Quest was designed to support a wide range of high performance and high throughput computing activities. However, not all applications and usage patterns can match directly to this environment. What technology, support, and funding models are necessary for support computing at Northwestern? What level and types of computing capabilities must reside on campus, what types of computing can be sent to the cloud, and how can we best leverage national facilities?
- **Complexity of computing.** The ways in which computing can be accomplished are continuing to diversify. Each platform requires its own level of education and training to be used effectively. For example, we know that in parallel computing environments the increasing degree of parallelization requires increasing levels of knowledge in developing efficient, scalable algorithms. What types of education and consulting services are necessary to not only educate and train in traditional computational research areas but also reach paradigms not as familiar with these computing technologies?

Visualization

Over the last few decades, the research community has become ever more dependent on visual representations as a means of better understanding increasingly complex phenomena. Due in large part to the entertainment industry's aggressive advancement of the field of computer-generated imagery (CGI), the potential for producing aesthetically complex informative visualizations became a possibility for research. However, the unique technical and artistic talents required to effectively utilize these tools and techniques understandably continue to be drawn into the world of digital entertainment. This has created a gap between the visualizations producible by many researchers and students and the visualizations necessary to provide highly informative 3D representations of research data.

External Trends

- In an increasingly visual culture, students are motivated to learn how to present results in a manner that encourages the successful comprehension and dissemination of complex science and phenomena.
- The decreased cost of GPUs and the advent of cloud technologies are bringing real-time 3D interactions to desktops, advanced high-resolution displays, and mobile devices - enabling high throughput of local and remote data rendering over commodity networks.
- Rapid evolution of graphics technologies and techniques leading to evolutions in the design and development of new visual methods requires considerable training and experience to leverage.
- Increasing fidelity of research data is requiring new methods for visualizing and analyzing data sets.

Current and Upcoming Committed Projects

- **Expanding visualization services** in the areas of interactive visualization, animation, and illustration to additional NU research communities, increasing impact on research, education, and outreach activities.
- **In concert with the Chemistry of Life Process Institutes' Center for Advanced Molecular Imaging, leverage efforts in the ongoing development of the Silverman Hall tiled wall display** to extend the facility to a more diverse research community.

- **In concert with the Feinberg School of Medicine, provide for an introductory visualization presence in Chicago** that will enable the University to direct researchers to existing services and better understand the nuanced needs of life scientists in the Feinberg School of Medicine.
- **Identify opportunities to support visualization needs of Quest users** in requiring advanced support.
- **Provide visualization facilities with appropriate networking support** to ensure capabilities for large-scale high volume streaming.

Near-Term Priorities (FY14-FY15)

- **Educate a broader audience** through targeted lectures and workshops on emerging visualization techniques and methodologies, core visualization concepts, and domain-specific solutions.
- **Investigate virtual GPU technology for streaming desktops** and cloud services as a potential solution for remote interactive visualization activities.
- **Involve students in the development** of highly informative visual material through internships and other work-study opportunities.

Longer-Term Priorities

- **Expand visualization services** to bolster Northwestern's efforts in aiding its researchers in effectively analyzing data for increased understanding of results and development of outreach and education components that can be used to train a new generation of practitioners.

Making Room to Do More in Community

- **Area for growth**, but targeted training and internship opportunities may help reach broader research communities.

Discussion Points and Challenges

- **Diverse Skill Sets Required.** The skill set required to effectively communicate visual representations of complex research phenomena extends far beyond the use of digital tools and technologies in the development of a given visualization. Concepts such as color, light, form, composition, and other artistic attributes are a key factor in successful development of informative visual material. How do we provide students with the comprehensive education that will enable them to effectively build these visual elements? How can we more broadly involve schools, such as the School of Communication, in the development of these skills?
- **Developing a sustainable business model for Visualization.** The FY12 expansion of visualization services enabled us to staff two new visualization positions (bringing the group to a total of three full-time staff members). Increasing the impact that these services will have on Northwestern research, outreach, and education efforts will require incremental additions of staffing and technology environments over time to meet University needs. How do we grow and fund Visualization Services that enables strategic growth of services that will broaden accessibility for the Northwestern research community?

Hosting of Research Cyberinfrastructure

Research requires infrastructure that not only supports scientific research but also leads its development into new directions. Data centers act as a platform for investments in networking, access to cyberinfrastructure, as well as benchmarking and evaluation. The pressure on Northwestern's data center hosting services has changed dramatically over the past five years. Today, three broad demand areas – administrative computing, storage of information, and research applications – are on separate growth tracks, with research demands presenting the highest call for facilities equipped with appropriate space, power, and cooling capabilities.

External Trends

- Many research universities are increasing development of comprehensive tools for treatment of infrastructure-related topics such as funding models, access rules to cyberinfrastructure, refresh rate of hardware, and personnel for management and administration.
- Many institutions are looking to the design of cost-effective, reliable central services that can be utilized by computational investigators in the place of departmental facilities.

Current and Upcoming Committed Projects

- **Expand the research co-lo facility** in the University Data Center by 8 racks. (See the “IT Infrastructure” discussion paper.)
- **Northwestern is in the process of instituting policies**, procedures, and installed security enhancements to satisfy the Health Insurance Portability and Accountability Act compliance requirements for hosting information and processing within the University Data Center. (See the “IT Infrastructure” discussion paper.)

Near-Term Priorities (FY14-FY15)

- **Develop a funding model to facilitate the expansion** of the research co-lo facility in the University data center by 8 racks per year (the current rate of growth).
- **In concert with the schools, develop a retirement model that cycles out old equipment** for modern compute infrastructure to make the best use of the University’s investment in data-center capacity.

Longer-Term Priorities

- **Develop models to reduce power consumption** in the HPC data center by evaluating the potential for energy saving in reduction of machine energy and cooling energy requirements. (See the “IT Infrastructure” discussion paper.)

Making Room to Do More in Community

- **Continue build out and evolution of centralized**, sharable research services such as Quest and Vault to meet a broader range of needs and thereby increasing participation while decreasing the need for departmental resources.

Discussion Points and Challenges

- **Today’s projects are joint, large scale, collaborative, and international.** The infrastructure that serves researchers in such projects must be accessible to all, and this obviously poses logistical problems to existing data center access models. Are there ways we should consider leveraging co-lo resources for larger grid computing activities? Should we consider new methods for account and ID management that would more easily enable collaborative access to these facilities?
- **Space, power, and cooling capacity in the University data center.** The University data center could be expanded to triple its current floor space and double its current ceilings for power and cooling. The primary driver for expansion will be disk space capacity (research and administrative), plus research computational capacity. Effective stewardship of these resources strongly signals a need to retire computational equipment that is four or more years old, because technology moves over time to provide more computing for less power in less space. The challenges are (1) how to fund refreshing shared resources, and (2) how to enforce policy to refresh or retire private clusters. (See the “IT Infrastructure” discussion paper.)

Networking

The requirements of research are driving not only increasing bandwidth requirements – they are challenging basic requirements at all levels. Data intensive research projects must be provided with a number of enabling network capabilities: (1) substantial additional low-latency network capacity to support high capacity/volume data streams and very low latency to ensure responsive interactive

instrumentation control, (2) enabling connectivity among all key collaborator research sites, especially for interdisciplinary research, (3) providing high performance communication services among those campus sites and among key external resources and collaborative communities that guarantee quantitative certainty and deterministic control over data stream path, and (4) significantly improved flexibility of these networks by offering end users multiple options for configurations that can meet the exact requirements of their research projects by enabling researchers to control their own network adjustments locally.

External Trends

- The sharing of massive amounts of data is becoming commonplace in several research areas, including high-energy physics and genomics. Traditional methods for shipping data on hard drives are quickly losing viability as the datasets being produced on instruments, supercomputers, or gathered from sensors are increasing in size and fidelity.
- Data is not necessarily located at its collection point. Simulation, modeling, and analysis of data are being accomplished everywhere - from local facilities, to national computing centers, to cloud services such as Amazon EC2.
- Data management is increasingly becoming a collaborative effort among international partners.
- There is now widespread recognition, including by funding agencies, that supporting research data requires networking services that are fundamentally different than those that support general types of traffic.
- End-to-end guaranteed network services have been developed for predictable data transfers among multiple distinct location endpoints. This capability is the basis of many specific research projects that must optimize the path construction and bandwidth reservation on real world production networks (e.g., national research and education networks and federal agency research networks).
- A Quality of Service (QoS) methodology for high-performance networks in data-intensive scientific applications has been developed to ensure optimal network resource utilization and avoid service interruptions/degradations.
- Specialized network services, which support collaborative science research teams worldwide, are increasing in use. These networks can create and control special integrated environments comprised of multiple resources at geographically separate locations (e.g., instruments, analytic appliances, compute clusters, storage, visualization displays, and others).

Current and Upcoming Committed Projects

- **NUIT is engaged in a multi-year project to refresh the general campus data network routers and switches.** After this is complete, all distribution routers will be connected to the core at 10Gbps at a minimum, with multiple 10Gbps added where needed. (See the “IT Infrastructure” discussion paper.)
- **NUIT just completed the installation of our first large-scale deployment of research dedicated, high performance 10Gbps access ports in Silverman Hall.** This project allows for any location serviced by the Tech distribution routing site to be upgradeable to 10Gbps access ports. This project also upgraded connections between both the Evanston and Chicago data centers and the core routers to 10Gbps.
- **NUIT is in the Request For Proposal (RFP) stage of refreshing the data center networks** to be 10Gbps capable. (See the “IT Infrastructure” discussion paper.)
- **Northwestern maintains high performance connections to advanced regional, national, and international research and education networks.**

Near-Term Priorities (FY14-FY15)

- **Increase the inter-campus network transmission rate to 100Gbps** to support research applications (See the “IT Infrastructure” discussion paper.)
- **Evaluate emerging National Science Foundation supported networking techniques for data intensive research**, such as methods for establishing “Science DMZ” zones to segment traffic, Software Defined Networking (SDN) for enhanced control by edge processes, and OpenFlow-based technologies for better network responsiveness to science applications.
- **In concert with the Feinberg School, the McCormick School, and the Weinberg College, plan for new specialized research network capabilities.** Identify key research projects that could benefit from such capabilities.
- **Increase deployment of specialized research networks** for use by University research programs (See the “IT Infrastructure” discussion paper.)

Longer-Term Priorities

- **The next few years with the introduction of next generation high-speed interfaces** will lead to a requirement of suitable aggregation solutions, and we should see a move to 100G and beyond to meet the growing need for bandwidth and the support of new research projects and educational opportunities.
- **Develop a service and appropriate funding model** for specialized research network services and staffing support.
- **Plan for 100 Gbps services**, which are now being implemented at many research campuses and national labs.
- **Identify appropriate funding models** for implementing equipment that can provide enhanced connection to the StarLight Communication Exchange Facility, including 100 Gbps services.

Making Room to Do More in Community

- <none>

Discussion Points and Challenges

- **Developing a high performance network infrastructure** to support multiple services for different communities while remaining cost-effective requires careful consideration of many issues – requirements, design options, and networking technologies. How do we identify and deploy high performance networks to research groups being impacted by existing network bottlenecks?
- **The current Northwestern campus network has been designed to provide generalized network services to a large community.** The network is optimized for large numbers of small data flows carrying small amounts of information, not for the large-sized individual flows required for data-intensive research. Large flows on the current campus networks are disruptive to smaller flows, inefficiently handled by firewalls, and subject to packet loss under the Transport Control Protocol (TCP).
- **Currently, researchers cannot customize the current general network configuration to meet their specific research requirements.** For example, some instruments require continuous large-scale data flows (to or from the device or both) using the full capacity of a 10 Gbps path for hours or days or weeks. Other applications require fluctuations between extremely high data rates using the full capacity of the network or no utilization at all. Common campus networks cannot support such extraordinary needs.
- **What IT services might be necessary to support specialized network resources** or should we expect local research groups to build the expertise necessary to operate specialized network capabilities?

Integrated Architecture for Research Cyberinfrastructure

Fewer and fewer researchers working at the frontiers of knowledge can carry out their work without research cyberinfrastructure of one form or another. Sophisticated software, visualization tools, middleware and scientific applications created and used by interdisciplinary teams are critical to turning flops, bytes and bits into scientific breakthroughs. It is the combined power of these capabilities that is necessary to advance the frontiers of science and engineering, make seemingly intractable problems solvable, and pose profound new scientific questions.

External Trends

- NSF's funding philosophy has evolved such that priority is given to linking advanced computing engines, archival data and digital libraries, observation and sensor systems, and other research and education instrumentation into a common framework.
- The research community is beginning to explore open source software platforms (HUBzero, nanoHUB, neesHUB, GlobalHUB, etc.) to support scientific research and teaching through an integrated platform available online.

Current and Upcoming Committed Projects

- No current projects.

Near-Term Priorities (FY14-FY15)

- **Explore technologies such as HUBZero** to determine if discipline-based portals to research cyberinfrastructure can effectively be developed and by useful to that research community.
- **Explore established technologies for enabling federated resources** to enable the aggregation of technologies to solve specific research needs.

Longer-Term Priorities

- **Deploy a discipline-based portal that provides access to well supported tools, technologies, and computational platforms** to enable new discoveries and provide a means for University researchers to identify the set of resources most applicable to their research problems.

Making Room to Do More in Community

- No current projects.

Discussion Points and Challenges

- **Maturity of this area is relatively low** with very few providers of integration technologies suited for research use. As such, significant overhead in time and funding may be incurred if there are no standards to adopt for increased interoperability.

Teaching, Education, Outreach, and Engagement

The growing complexity of research is producing equally more complex tools, technologies, and data options. Solid software development methodologies and practices become crucial when designing new algorithms and simulations addressing the problems of today and the future. New educational and work opportunities are necessary to train students in efficient use of research computing technologies and tools.

External Trends

- For many institutions the provisioning of specialized staff has become just as important as the provision of hardware and software resources for research computing.
- One-on-one communication with researchers is the best method of enabling partnerships and addressing needs.

- Research Computing departments at most institutions are leveraging their services to partner with faculty on grants.

Current and Upcoming Committed Projects

- **In concert with the University Library and the Provost's Office, relocate the A&RT Research Computing group** to the Science and Engineering Library on North Campus, which will encourage deeper collaboration with NU faculty in support of their research efforts. This may lead to successful funding proposals for investment in central research computing resources, such as Quest.
- **Extend workshop opportunities for the NU research community by:** expanding research computing workshop topics, depth, and frequency of training events; inviting off-campus leaders in research computing to focus on national research computing resources and opportunities; offering streaming media from core workshops; and in conjunction with faculty, extending training for students using research computing environments.
- **Continue membership in the Virtual School of Computational Science and Engineering** to provide graduate and postgraduate workshops at Northwestern with the latest high performance computing science topics and techniques.
- **Update the IT Research Computing website** to provide greater education and outreach for cross-discipline research services and support activities.

Near-Term Priorities (FY14-FY15)

- **In concert with the Feinberg School, the Kellogg School, the Weinberg College, and the McCormick School, identify opportunities for community building** and forums for feedback on research computing services and as a means to identify emerging needs.
- **In concert with the Feinberg School,** provide for an introductory research computing consulting presence on the Chicago campus in support of life science and medical science research.

Longer-Term Priorities

- **In concert with the Feinberg School, the Kellogg School, the Weinberg College, the McCormick School, the Office for Research, and the Provost's Office, develop a for-credit research computing curriculum** to provide extensive training to students in the use of research computing instruments (networking, computing, visualization, workflows, storage methodologies, etc).

Making Room to Do More in Community

- Review academic and service alignment between NU department curriculums and NUIT Research Computing support staff for the development of priority educational opportunities.

Discussion Points and Challenges

- **Sustainability of research computing support services.** Familiarity with scientific achievements enables NUIT Research Computing support staff to better assist faculty and campus research institutions by aligning our support resources and services to meet a broader diversity of needs. What opportunities and methods for involvement would have best benefit to Northwestern, its researchers, and research programs? What funding model should exist to grow staffing resources in support of research computing support services?
- **Building deeper collaborations** with faculty can aid the University in identifying potential partnerships with industry and national labs to develop, evaluate, and deploy new and powerful research computing services, architectures, and software technologies, which will enable Northwestern University to be at the vanguard of ever-advancing research programs. What role does research computing have in enabling these collaboration and relationships? What outreach opportunities should be undertaken to enhance our options?

- **Better integration with NU curriculums** may enable more thorough training and education on research computing technologies that are applicable to today's researchers. What other ways should the University look at for providing integrated education to our students in the areas of high performance computing, visualization, data management, and cloud computing?

Executive Summary: Administrative Systems

Northwestern has a wide range of administrative systems with extensive functionality including: the commonly understood “Enterprise Systems” supported from central units; systems that serve broad areas of the University but are supported in business units; systems that have emerged through a decentralized fashion and grow beyond the originating unit; and truly local systems.

The focus of the central units over the past number of years has been implementing core enterprise systems and the systems most closely connected to them. These investments have already returned great value, and these systems will be depended on for the foreseeable future. However, this focus has come with costs as well. The ability to change these systems is difficult and costly, their user interfaces are not known for their flexibility or ease of use, and the focus on implementing these large systems has crowded out development of enabling technologies and integrated data, which are needed for these individual systems to deliver their full value.

For the past several years, the top communicated need has been integrated data – for reporting and analytic purposes. Progress has been made with the growth of the Business Intelligence system, but much data is still silo’ed and difficult to integrate. Many barriers keep it that way: un-reconciled data definitions, independent support and development organizations, lack of resources to cleanse and integrate data into repositories, and lack of enabling technologies to ease the direct flow of, and access to, data.

In the area of integrated systems and the development of enabling technologies, the most important technologies in this set are a robust and flexible identity and access management (IAM) ecosystem and a Service-Oriented Architecture (SOA) framework. The IAM ecosystem exists, but it is brittle, inflexible, and will be end-of-life in three years. SOA is non-existent though the core enterprise systems have Web Services built into them. Both of these infrastructure improvements have been identified as significant priorities for many years with little real traction in moving them forward. Addressing the shortcomings in these enabling technologies will have a big impact on the IT teams’ ability to respond quickly and effectively to changing business needs, and they will greatly improve the user experience.

In the area of electronic workflow, two document scanning solutions exist on campus and online workflow remains rudimentary. This area has been identified as a priority and is getting increased attention with the pace of development and the new opportunities to move this forward.

An area for renewed attention is business continuity/disaster recovery. As the University’s dependency on online services increases and the opportunities for improvements from an infrastructure perspective advance, it is important to renew this planning. Having community, business owner and senior management input on requirements for restoral speed and completeness is necessary for this process.

Accessibility via smartphones and the proliferation of social media functionality are two sweeping trends whose existence has been reflected in the University’s administrative systems on a very limited basis.

While the needs and challenges of administrative systems are large, there are real opportunities for making room to do more. 1) The alignment of organizations involved in the production and support of administrative systems is fragmented both within the central units and between the central units and the schools. 2) Cloud computing offers many opportunities to save money and increase flexibility (though, as the trend to the cloud increases, so does the importance of enabling technologies built into it). 3) Costs associated with initial scoping and development, and ongoing maintenance can be greatly lowered if expectations for IT solutions to match existing business processes are reduced.

The following discussion paper presents expanded reviews of the above items, details on current work, work considered for FY14-FY15, opportunities for reduced effort, potential challenges, and discussion questions.

Administrative Systems

Northwestern has a very wide range of administrative systems with extensive functionality, which are critical in supporting the mission of the University and the day-to-day functioning of the institution. These systems include:

- The commonly understood “Enterprise Systems”, which are supported from central units (e.g. FASIS, SES, CATracks, EngageNU, NUFinancials, InfoEd, BI, FAMIS).
- Systems that serve the broader University but are supported in business units (Voyager, eIACUC, eIRB, ISIS, GRANITE, SIMS).
- Systems that have emerged through a decentralized fashion but have grown or are growing beyond the originating unit (OnBase, ImageNow, GATS, potentially the Weinberg College’s dossier system).

The focus of this discussion paper is on common needs and priorities across systems. We do not attempt to discuss needs/priorities within specific systems.

External Pressures on Administrative Systems at Northwestern

All of the trends listed at the outset in the overarching introductory section are relevant to administrative systems. For example:

- The user experience is expected to be high quality, dynamic, with real-time integrated services available for self-service and via multiple device types at any time.
- The administrator’s experience is also expected to have the characteristics as described for the user experience and cannot be rooted in manual processing of paper and recurring data feeds.
- The more people are able to improve services by finding new cloud-based offerings or via federations with systems at other institutions, the more demand will grow to rapidly integrate new solutions into the University’s existing ecosystem.
- The more people understand that data is available, and the more an institution can leverage data for improved decision-making, the more pressure there will be to integrate data for analytics.

For the last five to ten years, the focus in administrative systems at Northwestern has been on the replacement of the core enterprise systems and the systems most closely connected to them. These investments have returned great value to the University. The University will be dependent on these systems for the foreseeable future because of their strength, their leadership in their respective markets, the fact that there are relatively few realistic alternatives to them, the significant investment the University has made in them, and the exorbitant cost of switching to competing systems.

However, these advancements have not come without their attendant costs. The ability to change these systems is difficult and costly, their user interfaces are not known for their flexibility and ease-of-use, and the focus on implementing these large systems has taken attention away from attending to the needs of the foundation on which these individual systems depend.

Here now are significant challenges posed in these times of change for this set of systems:

- How can we achieve increased functionality and agility, and build better user experiences around these larger systems rather than be constrained by them?

- How can we find ways to leverage existing investments more broadly when the size and number of these systems keeps growing?
- How can we keep pace with the dynamic growth of the overall ecosystem that is fueled by the availability of excellent cloud-based complementary and alternative services?
- How can we overcome the isolation of the individual systems to enable analytics and integrated services?

The following sections work through these challenges and others to offer a vision of how we can begin addressing these dilemmas. After these sections, the Administrative System discussion paper concludes with overarching sections on “Insuring Continuity” and “Making Room to Do More in Community.”

Responding to the Challenges around Us

Within Administrative Systems, many areas have unmet needs. From among all such areas, we discuss seven that stand out from the rest, flagging two as acute needs and five as important needs:

Acute Needs

- Data Integration / Analytics Strategy
- Enabling Technology: Identity and Access Management

Important Needs

- Enabling Technology: Service Oriented Architecture
- Enabling Technology: Document Management/Scanning and Online Workflows
- Business Continuity / Disaster Recovery requirements
- Improving the User Experience
- Social Media / Community

The most acute need in Administrative Systems, as commonly identified in earlier lists of priorities and in discussions over the past year, is the integration of data and the ability to use that integrated data. Thus, this section begins with analytics and data integration, turns to a discussion of enabling technologies that are key in making information “flow”, and then concludes with a discussions of Business Continuity / Disaster Recovery, improving the user experience, and Social Media/Community.

Data Integration / Analytics

Summary

- The societal trend in this area is mirrored at Northwestern, where analytics and integrating data is one of the most keenly discussed topics of conversation.
- As the desire for cross-function information and analytical reporting increases, the need to have integrated systems instead of isolated silos becomes more obvious as a prerequisite to realizing the full value of the information contained in our individual enterprise systems. However, addressing these desires involves much more than a technological challenge. For example:
 - The combining of data is a complicated task with a development timeline that can be at odds with the needs/wishes of distributed business units.
 - Under our present approach, data integration is all done by a central development team, whose projects are selected by a Business Intelligence (BI) advisory committee. Work is limited to that which can be accomplished with existing resources, with the overall objective of evolving towards a full reporting infrastructure through selected projects. An important factor in

deciding priorities is the value for the institution as a whole, and this can leave pressing business needs of individual schools or business units unaddressed.

- The need to have integrated data can create tension with accepted rules of business privacy, or can require that expensive and complicated data security rules be built into the systems.
- The analytic tools themselves are not intuitive to most people, and yet a training infrastructure is still rudimentary.

Current and Upcoming Committed Projects/Activities

- Hiring of an Enterprise Information Architect to help facilitate the integration and architecture of the University's data.
- Developing a Data Warehouse directions paper.
- Performing a Gap Analysis of the current state of data warehousing and identification of broader infrastructure needs to support Data Warehouse and BI capabilities.
- Expanding the current governance structure to include an Information Management committee under the Administrative Systems Advisory Committee.
- Performing multiple BI projects, including: addition of Undergraduate and the Kellogg School Admissions data to support better admissions data reporting and student lifecycle analysis; addition of census, payroll and employee metrics analysis tools; continued rollout of data warehouse and analytic capabilities for the Office of Alumni Relations and Development; and discussions with the community about a possible Principal Investigator Portal for grant expenditure management
- Upgrading the Cognos BI tool.

Near-Term Priorities (FY14-FY15)

- Implementing the Data Warehouse solution that will result from an institutional discussion.
- Enabling technology projects to lay a solid foundation for data integration and integrated analytics capabilities (see below).
- Implementing BI projects that meet high priority business requirements and address infrastructure gaps. These could include:
 - A Principal Investigator Portal that integrates data from disparate systems to improve operational efficiency and reduce institutional risk. Such a project would also provide opportunities to build a solid data integration infrastructure and provide use cases to drive data access policy discussions.
 - An endowment stewardship reporting solution that integrates data from NU's endowment system with many other enterprise systems including CATracks, NUFinancials and FASIS.
 - Facilitating reporting on faculty activities that combines teaching and research activities, spanning the SES, FASIS and NUScholars systems.
 - Implementation of a universal, unique person identifier for faculty and staff to address specific data integration challenges between SES and FASIS.
 - Warehousing of Benefits data to provide better reporting tools to analyze benefits usage and predict future benefit offerings.

Longer-Term Priorities

- We anticipate predictive analytics and text analytics capabilities will become prevalent. Some of our constituent units would like to develop models to predict outcomes in many areas such as

admissions, student advising and fundraising. Increased staff expertise and a technology strategy are required to address this growing need at an enterprise level.

- Although it is not clear how quickly Big Data might grow in areas of higher education other than research, it's clear that we're on the verge of having access to data created in many areas of the institution. For example, data generated from learning management systems could be analyzed in identifying and advising at-risk students based on their online behaviors in LMS systems.

Discussion Points and Challenges

- Much progress has been made in developing central data repositories (or data marts) with standard data definitions, and data dictionary and reporting capabilities within individual business functions (student, alumni and development, financials, HR etc.). The ease in which data can be integrated, aggregated or shared across the functions is dependent on both infrastructure capabilities and policy decisions, and requires broader conversations, prioritization and agreements across the University.
- A first step in enabling data integration is development of an institution-level data sharing and access policy with buy-ins from the senior management and consensus among data stewards. An information management group might drive such discussions, and address data access and sharing policies, as well as shape our information infrastructure with common identifiers and common definitions within our enterprise systems.
- The complex security rules related to information access between business units and the need for protection of one department's information from another results in increased complexity of many of the business systems. It is understood that these rules have value in the organization, and their requirements need to be factored into any discussion about desired analytic capabilities.
- Is there a way to incorporate distributed units' desires and capacities for building analytics capabilities in with the central administration's commitment to analytics in a way that reduces effort and contention?
- Can a distributed training and support network be created that would reduce the demand for these services from the central BI team and free them to do more development work?
- What are the community's expectations as they relate to analytics tools? Is the current set of tools adequate, or should we be looking to expand them? For example, should a strategy around building predictive analytics capabilities be explored in the near future, or should we wait until the data warehouse and the integrated reporting capabilities mature more fully?

Enabling Technologies

As pointed out previously, cloud-based applications are not only increasingly available, they serve to lower the development requirements associated with offering a quality online service and they often offer cost savings. These are compelling drivers, and while there are attendant risks and potential downsides, there is no reason to believe that the attraction of cloud-based services will abate.

Along with this growth in systems will go a need to somehow integrate these systems (to a greater or lesser extent) with the University's administrative and academic "ecosystem." If this is done, as it is today, on a one-off, on-demand basis, the integration will be limited and the application development teams will find it increasingly difficult to find the capacity to develop new systems/services.

The only hope to scale the efforts of these development teams, improve agility, and foster improved customer experiences, is to develop a layer of "**enabling technologies**" that is either non-existent or underdeveloped at this point. The first two of these are a robust Identity and Access Management system and a robust Service Oriented Architecture.

Identity & Access Management (IAM)

Summary

- Identity Management defines who is a member of our electronic community and what attributes of members will be available for systems to make decisions on appropriate levels of usage and access. Access management is the set of business rules used by each application to grant appropriate permissions to a requester. These functions are essential to the security of all information and applications, and to confidently associate individuals with their electronic resources and work.
- The current IAM ecosystem has grown organically over the last 10-15 years, often being extended based on projects with short timelines and limited resources. In combination with the churn related to ongoing developments in the industry of the infrastructure and tools, this has limited the capacity to integrate new functionality more effectively as it grew, or to re-architect it for a more functional future.
- While the current Identity Management system handles the core Identity Management tasks effectively, it is a brittle and overly complex ecosystem that is hard to upgrade or extend, and does not lend itself to automating core tasks such as off-boarding a departing employee.
- As systems and functions become more distributed on and off campus and project lead times decrease, it is increasingly important to have an uncluttered core identity management environment with well-defined identities and an industry standard architecture.

External Trends

- Growing use of third-party, offsite systems that depend on standardized Identity Systems with well-defined identities smoothly flowing through them.
- Growing need for electronic identities and credentials (e.g. passwords) to be valid between institutions to simplify administration in support of business partnerships.
- Growing acceptance of external identities (e.g., Facebook ID, LinkedIn ID, Google ID, etc.) by institutions to encourage non-community members to establish a relationship with the institution under controlled conditions.

Current and Upcoming Work

- Finish the requirements-gathering phase of the Identity and Access Management (IAM) Initiative and propose a roadmap of high-value projects for the next 2+ years.
- Hardware and software upgrades, implementation of two-factor authentication, attaining at least silver level certification from InCommon (a federation providing a platform for sharing trusted identities between U.S. education and research communities), local customizations to Northwestern's identity systems.

Near-Term Priorities (FY14-FY15)

- Higher-value projects as determined by results of the requirements-gathering phase of IAM initiative.
- Deploy IAM functions for support of cloud-based applications, especially for authentication using Northwestern NetIDs and credentials.
- Reduce and simplify the access rules embedded in the Identity Management System wherever possible to facilitate the move to a new Identity Management System in FY14 and FY15, and improve the agility of the Identity Management System and its supporting team.
- Continue to review and monitor the latest Identity Management software solutions.

- Support projects including EngageNU, and the University Library's move to a cloud-based version of Primo.

Longer-Term Priorities

- Replace the current IAM software before it goes end-of-life in FY15. This is an 18-24 month replacement project, so the highest prioritized enhancements to the current Identity Management system will need to be completed in the next two-plus years, with subsequent enhancements coming after the software changes are completed.

Making Room to Do More in Community

- Better defined identity information is a necessary requirement for enabling automation of the on-boarding and off-boarding of employees and the automated provisioning and de-provisioning of access to systems.
- Well-defined Identities in a standardized Identity Management system will facilitate the integration of cloud-based systems with the University.

Discussion Points and Challenges

- Improving Identity Services is ultimately more of a business process challenge than a technological one. How will this work get prioritized in the business units?
 - Identities needed for use by our business processes need to be precisely defined so the proper identity attributes can be exposed to, and consumed by, the administrative systems offering the services.
 - In order to make the Identity System more nimble, access rules for systems need to be taken out of the Identity System and placed in the surrounding systems where they logically belong. This architecture makes the core identity system more nimble, and allows the access rules to be built and maintained on a system-by-system basis instead of becoming a spaghetti pile of access rules at the center.

Service-Oriented Architecture (SOA)

Summary

- As a necessary component for increasing agility and ability to transform and automate our business processes around our Peoplesoft core, we need to increase the capabilities to develop new functionality in a more lightweight fashion, and integrate the resulting applications, services and data interfaces in a more robust and seamless fashion.
- Integration between applications and retrieving information from central databases are important prerequisites for integrated online services. Today, integration is based upon periodic exchange of batches of data and information retrieval is implemented through similar batch transfers.
- Future information exchange requirements between applications (both cloud-based and campus-based) must be in real-time. Agility to create new applications from existing databases requires standard, known and secure interfaces to data. The integration method must be abstracted to permit regular software upgrades to all systems without endangering the communication between applications. Modern software development techniques use Service-Oriented Architecture and Web Services technologies to achieve these desired goals.
- Having standardized Web Services in place for the core enterprise systems is a key component for removing enterprise system development teams from the never-ending need to create, and then monitor and enhance, data feeds for every existing and newly created system that needs data from a University system of record.

- It is also a key component for making data available in systems other than the “source system”, and for enabling the automation of online tasks and transforming physical paper work processes into online self-service processes.
- Once the architecture is in place, services will be built, “published”, and then reused over and over as the need arises for new systems that need to send and transmit data with other systems.
- Implementing this architecture is a multi-year project that can be done one service at a time. However, it must be done with an enterprise portfolio of services in mind and planned for. It requires new hardware and software with people to support it, effort to define the services and what they do on the business-side, and an ongoing commitment to manage the portfolio of services. But ultimately, this will free us to provide better applications more quickly.

External Trends

- There is an increasing use of third-party, offsite systems that need to send functionality and data back and forth with onsite administrative systems; the industry standard for data exchange is Web Services.
- Mobile applications are dependent upon access to data and applications through Web Services.

Current and Upcoming Committed Projects

- SOA paper developed and being discussed.
- Business opportunities being identified.
- Determine the technology infrastructure and products required to support the business opportunities that are defined.

Near-Term Priorities (FY14-FY15)

- Implement an Enterprise System Bus architecture.
- Create a Web Services governance body as a governance committee under the Administrative Systems Advisory Committee.
- Set a standard that all future new data exchanges will be done via Web Services instead of hand-tooled data interfaces.
- Begin creating Web Services to handle standard and high-value data exchanges, and adjust “back office” business processes to accommodate the usage of these Web Services.

Longer-Term Priorities

- Eliminate all existing data feeds and replace them with Web Services

Making Room to Do More in Community

- Instead of hand-tooling data feeds, Web Services can be published and reused over and over (e.g., vendor changes for Employee Benefits), thereby reducing the never-ending operational tasks of building and maintaining data feeds for every existing and new system.

Discussion Points and Challenges

- In order to scale the effort and investment in this architecture, time will be required from systems of record to develop Web Services and re-orient their business processes to their use. How will this be prioritized within these units?
- In addition to the enabling infrastructure, a major area of conversation for the administrative systems is related to the needs for infrastructure, policies, practices and tools to more effectively

use and report from and across our systems. In many recent consultations with the community this has been identified as the number one priority for improved administrative systems.

Document Management / Scanning and Online Workflows

Implicit in the external pressures on Administrative Systems at Northwestern are technologies that enable more efficient online services: document scanning/imaging technologies, and online workflow platforms. If we are to address customer satisfaction requirements for online services and back office efficiencies, these technologies will need to be combined within a service-oriented architecture.

Summary

- Two different document scanning/file management solutions are well-established at the University, each serving a needed function with a reputable solution. As of this point in time, these units are not in conflict with each other, and requiring one set of units to switch to the other product would be difficult and costly.
- While there is some integration of images of scanned documents into workflows (University Enrollment), most implementations of document scanning are efficiency solutions to the difficulties of storing, tracking, and accessing the proliferation of paper documents.
- Interest is growing around campus to integrate these document repositories with data in enterprise systems and thereby move current manual, paper-based processes to an online workflow. Both document management solutions offer tools for workflow, but require consultants to implement.

External Trends

- Three layers of content management are emerging in the workplace:
 - Repositories for final versions of documents.
 - Team collaboration sites for documents that change or are tied to time-delimited projects.
 - A distributed, individual-oriented layer where consumer-oriented products like Dropbox, Google Apps, and Box.net are used.
- These layers correspond to solutions that exist, or are being discussed, at Northwestern:
 - ImageNow / OnBase
 - SharePoint / Google Drive? / Box.net?
 - DropBox / SkyDrive /Google Drive/ iCloud / Box.net

Current and Upcoming Committed Projects

- Based on recommendations from Gartner and positive experiences on the Qatar campus, we will be investigating Microsoft SharePoint's abilities to provide two important and relevant functions: (1) integrated search across and access to the two document scanning / file management systems(ImageNow and OnBase), and (2) a lightweight application development environment that could define and drive online transactions and workflows.
- A scalable implementation of workflows should be built on a set of Web Services as a part of a planned Service-Oriented Architecture.

Making Room to Do More in Community

- If SharePoint, with its array of plugins such as Nintex and its built-in FAST search engine, can fulfill the promise it may hold, its implementation could provide a development platform that makes the creation of online workflows easier, quicker, and less costly than utilizing the functionality built into

the two document scanning solutions we currently have on campus.

Discussion Points and Challenges

- We should coordinate a structured investigation of SharePoint’s capabilities in this area that involves a partnership between NUIT and selected business units before further fragmentation of effort takes place.
- What is our strategy for expansion of OnBase/ImageNow and how might SharePoint play into this?

Business Continuity / Disaster Recovery Requirements

The requirements for Business Continuity/Disaster Recovery continue to evolve with the increased dependence on, and complexity of, our underlying business process. Additionally, our technology options to mitigate risk associated with loss of business continuity increase. Determining the appropriate levels of investment in this area comes down to business choices that have to be made for each application as to the speed and completeness of the restoration process, which characterize its level of protection. (See also the “IT Infrastructure” discussion paper.)

Improving the User Experience

Many aspects of the user experience have already been mentioned in the preceding discussions: using new cloud-based, third-party systems with enhanced user interfaces; creating an environment to develop online real-time workflows; and having systems that are integrated with real-time flows of data between systems. There are other aspects of the user experience that can be addressed as well if needed.

Summary

Portal

- External trends toward easy-to-use, personalized, highly integrated systems are orthogonal to un-integrated systems requiring multiple access points and repeated logins.
- The current implementation of the NU Portal is limited:
 - Heavily slanted towards administrators and access to the financial system and iBuyNU in particular.
 - Not all enterprise systems use the same authentication system, thereby blocking their inclusion in a unified portal system or a Single Sign On (SSO) solution
 - Additional “portals” are being discussed in addition to the NU Portal (e.g., a FASIS portal, a Principal Investigator portal).

Optimized User Interfaces

- Default presentation layer shortcomings:
 - The presentation layer for many of the core enterprise systems is far from helpful (e.g., Kronos in general, PeopleSoft’s absence of a “back button,” or its inability to have more than one window open at a time). In places this functionality is exceedingly challenging, and yet the systems are too difficult to replace and local customizations are costly to create and especially to maintain.
 - If Web Services were activated in these systems, and a Service-Oriented Architecture were in place around them, these situations could be addressed, if desired, by the creation of a new presentation layer built outside of the core application. Through Web Services, the locally developed software would be insulated from most underlying software changes – saving future effort.

- Because systems can be accessed by a wide variety of device types – smartphones, tablets, laptops of multiple sizes, desktops with a variety of screens attached to them – systems need to be accessible via user interfaces that work well on the smaller-format mobile devices.

Current and Upcoming Committed Projects

Portal

- Multiple projects are slated for the NU Portal to broaden its utilization:
 - Creation of a mobile/tablet interface to increase its usability across multiple device types.
 - Creation of sets of portlets to address non-administrator constituencies: students (Grants Programs, Box offices, Athletics, Events – by February 2013), faculty/staff (HR Quick Links, Collaboration, Research Composite).
 - More general usage portlets: Bookmarks and TagCloud/Search.

Mobility (See the “IT Infrastructure” discussion paper.)

- The utility of the current mobile framework used to provide Northwestern mobile applications has lost its advantages as a platform, and a transition to a framework that is more adaptable to addressing Northwestern’s needs is being investigated.
- While smartphone and tablet usage continue to spread rapidly throughout the population, providing improved mobile access to administrative systems has yet to be widely prioritized beyond the existing mobile services. However, there are responses to this trend on campus:
 - A discussion paper has been written on this topic and is being circulated throughout the University to raise awareness and encourage the alignment of resources where appropriate.
 - University Relations has created a mobile view of the Northwestern website.
 - NUIT has begun to develop “reflexively designed” interfaces (the design of the interface changes in relation to the type of device accessing the application).
 - In recognition of the growth of mobile devices, the enterprise system vendors are beginning to develop mobile interfaces for their systems. It remains to be seen where these will be developed and how good they will be.
- Should the need for improved mobile access become more tangible, it will be important to have a Service-Oriented Architecture in place for mobile application development.

Making Room to Do More in Community

- Creation of a foundation of re-usable (develop once; use many times) Web Services that deliver data to user-friendly applications. These Web Services would be discoverable and follow standards that make them easy to use.
- Rather than developing multiple different portals, standardize on one and have common architectures and interfaces.
- Develop small task-oriented applications that can be used from mobile phones or from the NUPortal. These applications could use data and business rules from multiple administrative systems. (See the “IT Infrastructure” discussion paper.)
- Development of a common mobility framework and collaboration across IT units. (See the “IT Infrastructure” discussion paper.)

Discussion Points and Challenges

Portal

- Is having one NU portal a priority? Are all constituencies equal in including them into the portal?

- Relationship of “regular” portal with a mobile portal? What is the relationship of the upcoming SharePoint implementation to the NU portal?

Social Media / Community

Many corporations have begun adopting enterprise social networks to realize the benefits of community interaction, using new tools comparable to Facebook, without mixing the personal and enterprise environments. However, this external trend of social communities/interaction is not as widely enabled within universities as it is in the surrounding world.

At Northwestern, the two ends of the student lifecycle have been the focus of most activity in this area, with Facebook sites being used for incoming students, and the EngageNU project moving social software into the center of the online experience being provided for the alumni community.

Interest in this functionality is also emerging in the teaching and learning side of the Northwestern community to expand the learning experience beyond the classroom. Examples include: SESP’s MSLOC program, which utilizes the Jive software that is core to the EngageNU project; interest in LoudCloud (a social media enabled Course Management) led by the Medill School; the Drupal Commons initiative in the School of Communications’; and many other investigations happening in ad hoc ways across campus. (See the “Educational Technology” discussion paper.)

The core enterprise systems have not built this functionality into their systems, and it appears premature to prioritize finding a social networking platform which might span our requirements. First, we should better understand the real requirements and the real value of an integrated social network environment. At this stage, there is great interest in the outcomes of the efforts noted above to see what they can tell us about the ease and attractiveness of creating these online communities.

Making Room to Do More in Community

Opportunities for increasing capacity that are described in the overarching introductory paper are highly relevant here:

- Utilizing cloud computing.
- Relaxing the requirements on fitting solutions to existing business processes.
- Reducing the “noise” in the system by better aligning the organizational parts.

The third opportunity listed above deserves additional comment. The Northwestern IT community has grown up organically over the past twenty years, and there are great opportunities for improved efficiencies and effectiveness if we can reduce fragmentation, both within the central administrative units and between the central units and the IT units distributed around the University.

- Many portions of the University IT Organizations (IT@NU) have local resources for development and support of unit-based initiatives. Currently these resources are only infrequently combined into a planned deployment team for improvements across units. Wide-spread improvements, requiring multiple units to coordinate efforts can require lengthy negotiations versus unit-based project demands. With several important institution-wide requirements identified as acute needs (e.g. IAM improvements, SOA & Web Services, portal, mobility, BC/DR) we need to find ways to agree on priorities and improve collaboration among units.
- Within the larger University community, development of administrative systems has taken place to resolve local requirements when necessary or when increased functionality is desired. This has resulted in investments in systems which are not often extended more broadly on campus, in the

duplication of systems, and unplanned integration costs to connect local systems to central administrative systems.

- With the emergence of cloud computing, the barriers to finding third-party vendors to provide value-add systems is now lower than ever before, and without increased communications and a commitment to a new coordinated way of addressing our needs and challenges, the possibility of increased fragmentation is very real. The new IT governance framework and a commitment by the IT@NU community to look for partnerships and alignment opportunities before acting independently could combine to help overcome this historical fragmentation.

Current and Upcoming Efforts

- Multiple partnerships between NUIT, Enterprise Systems, and schools on applications (Graduate applications with McCormick, the Kellogg School student system projects, Graduate applications, and possibly the Weinberg College's Student Dossier):
 - These efforts should provide a forum for discussing the improved alignment of application development across the institution so when a locally-developed application needs to flow to the center, it will do so with less effort required.
 - They should also lead to a common development environment and systems architecture, less duplication of effort and more effective use of IT resources within the University.
- Expanded conversations across organizational boundaries:
 - Enterprise System presentations to the Administrative Systems Advisory Committee (ASAC).
 - Increased cooperation across Enterprise Systems:
 - Developing calendars and more encompassing discussions about priorities for shared resources.
 - Improvements in cooperation to reduce fragmentation/complexity (e.g., websites, project proposal reviews, security access requests). Task-oriented approach rather than a silo'ed system approach.
- Portfolio Management improvements:
 - Better management of the Project Initiation process within NUIT to better insure the availability of resources and the prioritization of the most important projects.
 - Improvements in Governance to help set portfolio priorities.
- Project management improvements
 - Better Change Management within NUIT when projects have difficulties, so that impact on other projects can be minimized and/or affected projects can have more advance notice of the impact on them.
 - Better management of projects through use of a common project management framework.

Near-Term Priorities (FY14-FY15)

- Project management improvements:
 - Manage scope creep better. When one project keeps growing, multiple other projects are affected.

The Larger Context: Other Project Needs

The seven areas presented in this discussion paper are common infrastructure needs that span all of the enterprise administrative systems. There are also significant priorities within each of the functional areas. Over the past year many issues have been identified, and this section very briefly identifies some of these priorities. It is important to note that this list is not exhaustive and just represents some of the activities vying for attention in some administrative areas.

- **Alumni/Development:** Implementation of the online alumni community platform; increased integration of relevant data from student, HR, and other systems with the alumni/development system; increased adoption and enhancement of reporting capabilities for alumni/development data; migration of the online giving function to the new alumni community platform; development of integrated stewardship reporting capabilities; and migration of volunteer fundraising function to the new alumni community platform.
- **Faculty and Staff Information Systems:** Conflict of Interest for research faculty, staff, annual faculty conflict of commitment conflict of Interest, human subject COI disclosures; Upgrade Kronos for improved user experience; enhance eRecruit for Staff and implement eRecruit for faculty and post docs; paperless appointment and position process for Payroll; Graduate Student Interface; implement ePerformance for staff.
- **Facilities Systems:** major upgrade or potential replacement of facilities management system.
- **Financial Systems:** upgrade of core financial system and associated reporting/warehouse; expansion of online, workflow-enabled financial processes, including employee reimbursement and purchase order changes; increased integration between financial and alumni/development systems and imaging databases; campus-wide rollout of online annual budgeting capabilities; delivery of forecasting and additional financial planning capabilities, etc.
- **Library Systems:** replacement of circulation, acquisitions, and catalog system (Voyager), the digital repository.
- **Research Administration:** improvements and updates in many major systems including, institutional animal care and use application (eIACUC), institutional review board application (eIRB), innovation and new ventures software (Wellspring), ISIS, etc.
- **Student Information Systems:** school access to electronic student documents, electronic forms for undergraduate schools, class planning, scheduling and enrollment, academic advisement, new University class search, additional admissions data to support BI, developments to accommodate online education (e.g. 2U), etc.

Executive Summary: Focus on Service

It is the goal of IT@NU (the collection of all IT delivery organizations at NU) is to deliver the best quality services within our environment, while continuously working to remove barriers to success. Priority should be placed on activities that continue to make technology easier to use, provide administrative tools where they are most effectively utilized, reduce support redundancies, and make support easier to obtain when necessary.

The external trends that affect the delivery of IT services at Northwestern – “always on”, mobile access, real-time and self-service workflows, usability issues driven by the commoditization of IT and cloud computing - are documented in the Introduction. This section focuses on device support and service management.

Device Support

- Priority should be placed on the management of institutional devices where possible. Examples already include: desktop backup, software distribution and desktop management, remote desktop support, and desktop encryption.
- Expand the use of Network Access Control to prevent compromised devices from connecting to the network and improve self-remediation.
- Given the spread of Apple computers throughout the community, strive for equal functionality for Apple when considering service solutions, whenever possible.
- Software and desktop virtualization can be an effective delivery option in situations where software licenses need to be optimized, data security needs to be insured, or device-independent delivery of services needs to be optimized.
- Cloud services that are designed for widespread audiences can deliver both improved usability and economies of scale.

Service Management Strategies

Support for IT services at Northwestern is provided by a myriad of IT organizations. Sometimes this mirrors the distribution of the IT services that are provided, sometimes it is a result of the need for various units to provide differentiated levels of support, and sometimes it is just a historical legacy. To improve user support, these need to be continually examined and optimized, where possible. Over the past several years, a willingness to partner and collaborate is growing within and between the IT@NU organizations. Multiple opportunities exist for this trend to continue including:

- Continue development of shared service models.
- Further develop the Catalog of Services offered by IT units, and the Service Management platform that is built on top of it, building this collectively with partner IT organizations wherever possible.
- Simplify solution offerings (e.g., video conferencing).
- Standardize to the extent possible bug/defect tracking systems.
- Create a shared database of IT contracts to improve vendor management and reduce costs.
- Prioritize the early involvement of users and user support teams in project design stages.

The following discussion paper presents expanded reviews of the above items, details on current work, work considered for FY14-FY15, opportunities for reduced effort, potential challenges, and discussion questions.

Focus on Service

Northwestern University attracts very capable and passionate faculty, staff, and students. The University IT organizations (IT@NU) work to deliver top quality systems and services so that the community can be highly productive and effective in research, teaching, and administrative pursuits.

IT@NU refers to the central and decentralized information technology units and departments that exist throughout Northwestern University for the purpose of supporting faculty, staff, and students in their use of technology, devices, and systems. IT@NU includes system owners and developers and those who directly assist customers with the purchase, deployment, and support of hardware and software. Together we work collaboratively to provide the best possible IT customer support and service to our shared customer base.

Faculty, staff, and students at Northwestern University expect the technology offerings at the University to perform as they do in the consumer market space. IT@NU and the services we offer are continually compared to market leaders such as Amazon, Google, Dropbox, and Apple. The community expects easy-to-use technology that is readily available with minimal complexity.

External trends that impact the perception of IT service delivery at Northwestern include:

- Fast, reliable, consistently delivered services at “any time” on “any device” that “just work.”
- Mobile devices as a handheld “life tool” to look up information or transact business at any time.
- Cloud based or virtualized services that easily work across all device platforms and remove the need to store data locally.
- Increasing use of video, texting, and social media.
- A society that is increasingly online for socialization, household finance management, shopping, education, and more.
- Easy access to IT support when transacting business online that is prompt, effective, and available when needed (even in the middle of the night or from around the globe).
- Products that encourage a customer to “try-to-do-it-yourself-immediately” when it comes to general technology troubleshooting and set up of devices.

It is the goal of IT@NU to deliver the best quality services within our environment, while continuously working to remove barriers to success. Recent progress has been made to identify and develop shared service opportunities in an effort to simplify the delivery of IT services across campus. Investments in Information Technology Service Management processes within schools and departments are setting the stage for continued service delivery improvement and alignment with the academic and administrative functions of the University. Priority should be placed on making technology easier to use (anytime, anywhere), becoming user device agnostic, and focusing support functions to reduce redundancy.

For the purpose of this discussion paper we have categorized the trends and potential projects associated with the prioritization of service to the NU community into two themes: device support, and service management strategies

The rich diversity of disciplines at Northwestern and the unrelenting pace of technology change will require a willingness to partner and collaborate within and between the IT@NU organizations. An ongoing process of reviewing and focusing services is vital to ensure the best use of University resources. Many of the items described will result in increased efficiencies and reduction of effort in certain areas so that they can be redirected to other priorities.

Collaboration and institutional commitment is required to fully embrace a “service as a strategy” philosophy and deliver IT services at NU in a coordinated way that compares favorably to the open market.

Device Support

The differentiated needs of the community, the rapidly evolving nature of internet tools and access methods, the consumerization of IT, and the distributed nature of IT on university campuses have resulted in the use of a plethora of computing devices (e.g. Mac, PC, Linux, tablets, ultra books, desktops, laptops, mobile phones), operating systems (Windows 7, Windows XP, OS X, Snow lion, Ubuntu 12), and internet browsers (e.g. Safari, IE8, IE9, Chrome, Firefox, etc.). This reality coupled with administrative systems that are inconsistent in their requirements (e.g., Java versions, browser type, OS, etc.) often frustrates faculty, staff, and students. The perception grows that IT@NU services are not functioning seamlessly. Along with continued device multiplication in personal environments and blurred lines between personal and professional hours in the day, we face further degradation of customer confidence.

The University has an opportunity to enhance the customer experience, improve customer access to systems, while supporting data security and system reliability by moving to more managed environments and applications where appropriate and where necessary.

Current and Upcoming Committed Projects

- **Ubiquitous Network Access Control.** Those who are responsible for information security and those who are negatively impacted by our coarse methods of managing security in the event of necessary remediation to security threats would benefit from wide deployment of network access controls. This solution should be deployed across the entire wired and wireless campus network, significantly improving our campus security position and improving network services to clients across campus.

Near-Term Priorities (FY14-FY15)

- **Embrace cloud services.** Cloud services are easy to use because they are built with the consumer experience at the forefront of their design while leveraging economies of scale across multiple organizations. This results in improved customer experiences at a competitive price point. The University should evaluate the risk-versus-reward on a case-by-case basis, emphasizing that data is adequately protected. A current example under consideration is the possibility of deploying a cloud file sharing service with a trusted service provider. This service will be designed to: 1) give better functionality to those using University services, and 2) encourage those who are currently using “untrusted” file sharing/storage services so that University data can be properly retained and protected while providing an easy to use, customer friendly interface. Cloud services should always be investigated as potential solutions to University business problems.
- **Virtualization of software and/or desktops.** By leveraging a virtualized software or desktop environment, centralized systems and platforms can be accessed regardless of the user’s operating system or device. University data can be retained and managed centrally to reduce the risk of improper access. Software licenses can be shared, reducing cost to the institution. Several NU schools have used this technique to improve faculty and student access to high cost software titles. Virtualized desktops would be a natural progression as we better understand how to “work in the cloud” and we begin to view devices as merely access points to information.

- **Embrace Apple hardware as “standard”.** Recent analysis shows that 60% of our students bring an Apple device to campus and 45% of faculty and staff use Apple devices as their primary work device. To enhance customer perception of IT@NU services, Macintosh and iOS devices should be fully supported and newly deployed systems should attempt to have parity of features and functionality.

Discussion Questions and Challenges

- Are there new opportunities for campus collaborative projects to better support the distributed end point device environment?
- How do we evaluate existing and potential services to improve customer service and reduce overlap?
- Is virtualization of software applications or desktops seen as a priority at this time, and if so, how can we collectively resource such an endeavor?
- Can we develop a methodology to help determine when a cloud solution is the best solution to meet an expressed need for Northwestern effectively weighing the risks and benefits?
- How do we address rapidly changing needs and scope within our environment?

Service Management Strategies

Effective technology organizations develop service strategies that align with the overarching mission of the institution. Documented and repeatable processes increase service reliability, resulting in improved customer satisfaction. At times, the decentralized and somewhat disconnected nature of IT@NU support organizations can create variance in the end user experience. In addition, the overlapping nature of a faculty member or student’s affiliation with the University can create confusion and frustration as they attempt to navigate the various IT support areas available on campus.

By considering the following options, the University has an opportunity to develop shared best practices, processes, and workflows that will enhance customer satisfaction:

Current and Upcoming Committed Projects

- **Service Portfolio definition.** Documenting the services that IT@NU provides and the institution’s associated service and operational level expectations will aid in better managing the expectations of faculty, staff, and students. Service level expectations that exceed the available allocated resources should be highlighted and explored further.
- **Investigate, develop, and deploy shared service models.** Working together and combining IT resources from across campus results in consistency of the support experience across NU, the development of a shared knowledge support group, and increased purchasing power. We continue to validate effectiveness, and as appropriate, invest in the expansion of currently deployed services including: desktop back up appliance (CrashPlan Pro); software distribution and desktop management (Altiris); remote desktop support (Bomgar); and desktop encryption (PGP). Shared service expansion opportunities include: Mac OS standardized imaging; Windows Server Update Services; Windows 8 standardized imaging and collaborative system deployment.
- **Service Management Platform deployed.** Through a collaborative process, the University has purchased Footprints, a software solution designed to automate and manage standard IT service management processes. The platform includes integrated Incident, Request, Problem, Change, Configuration, and Knowledge management modules. The system is designed to facilitate easy transition of information between central IT units and the schools/departments, resulting in faster resolution times and a broader understanding of issues that need to be addressed across the University. As opportunities for improvement are uncovered through metrics, whether it be with

people, process, or technology, IT@NU can begin to address them, thereby improving the customer experience.

Near-Term Priorities (FY14-FY15)

- **IT Project Management framework enhanced.** Effectively managed projects result in an increase in customer satisfaction and efficient resource management. A variety of project methods are in use to varying degrees across IT@NU (e.g. WCAS and Library using SCRUM, NUIT and Project Café using tailored frameworks). NUIT is making an effort to streamline its process so it can be effective while not being burdensome. Involving other IT@NU representatives in a larger discussion and process to better coordinate projects would be a goal for the future.
- **IT contract catalog and data tracking.** NUIT, NU Purchasing, and the Office of General Counsel review and approve technology contracts on a regular basis. Centralized tracking of these contracts including the system owner, features and functionality, and leveraged data elements that is shared with IT@NU could improve our ability to streamline support processes, share resources, manage data that is sent off campus to service providers. For maximum effectiveness the catalog should be regularly updated and audited on an annual basis.
- **System deployment with the end user experience in mind.** To ensure that University systems are widely embraced and understood by the community, resources need to be focused on selecting and deploying user friendly solutions. Usability considerations should be automatically included and involve those who work most closely with the customers from the projects inception.

Longer-Term Priorities

- **“Crowdsourcing” for IT Support.** Wikipedia defines “Crowdsourcing” as:
“a distributed problem-solving and production model. In the classic use of the term, problems are broadcast to an unknown group of solvers in the form of an open call for solutions. Users – also known as the crowd – submit solutions. Solutions are then owned by the entity that broadcast the problem in the first place—the ‘crowdsourcer’.”

By developing and leveraging this model for IT@NU, we draw from expertise that exists across the institution and build communication channels and relationships that will result in increased productivity through collaboration.

Making Room to Do More in Community

- **Standard bug/defect tracking tool and process.** Customers are frustrated when software or services do not work as designed. It is referred to as “a bug.” Consistent and shared tracking of these issues will result in better identification so that they can be addressed and resolved with the vendor and/or appropriate IT@NU group. With the myriad of systems that are managed and deployed, a shared platform for this type of tracking and identification would highlight any overlap in issues that may exist in similar products (e.g., PeopleSoft software) thereby increasing awareness and expediting resolution.
- **Platform simplification.** The University has many software solutions available for accomplishing similar tasks. For example, video conference options include Lync, Adobe Connect, Skype, MCU, Vidyo, and Google Video. This creates confusion and support complexity. Multiple web content management systems, customer relationship management tools, and document management solutions are also in existence across the organization. Customers are looking for IT@NU to work together to simplify the options so that reliable services are easy to identify and use.
- **Enterprise system customer communications and support alignment.** The NU community does not easily differentiate between NUIT and other distributed support units (including systems, schools, or departments). To the end user, everything is just “IT.” As such, IT@NU has an opportunity to better align our communication and support processes so that we do not send conflicting messages about

how technology solutions perform within our environment. As an example, coordinated testing of a new browser or operating system and sharing the results across the IT groups will improve the ability of smaller local IT units to support their customer base by increasing their expertise in an area they may not have had time to personally investigate, and could reduce testing redundancy across the various IT@NU groups.

Discussion Questions and Challenges

- How could the various enterprise systems staff work together to improve testing, usability, support, and communications? How might this be achieved?
- Are there further enhancements to the service management environment that would lead to increased effectiveness in support of the University community?
- How do we compare ourselves to peer research universities in the area of customer service and support? How should we?

Executive Summary: Information Security

Information security is of increasing concern in our society. This concern manifests itself in regulations for higher-education institutions (e.g., protection of student personal information) research institutions (e.g., human research protocols, protection of personally identifiable information, protection of funded research data and results) and healthcare institutions (protected health information). Northwestern is in all three of these categories.

The University's level of risk for protecting the data we collect, produce and store is increasing with the size and complexity of the data being gathered, analyzed and retained. The University must strive for a uniform awareness of our stewardship responsibilities and consistent application of security practices across its distributed organizational structure.

For our environment, security concerns break down into two classes: reducing vulnerability and deflecting direct attack. The former encompasses preventative measures and correct business procedures to reduce potential points where information could be accessed or systems compromised. Reducing vulnerability is not limited to electronic resources, but also applies to paper files, recordings, etc. Some regulations mandate particular data handling methods or business processes.

The second class, deflecting direct attacks, combines specialized systems (e.g., firewalls, intrusion protection, multi-factor access control) with education of all personnel to the potential for "social engineering" attacks (email phishing, forgotten password pleas to the help desk, etc.). This is especially important for research institutions where virtually constant attempts are made to steal intellectual property.

Society's elevated concern is increasing at the same time as disruptive changes are creating new risks. Cloud computing, Bring Your Own Device (BYOD) strategies, and collaboration inside and outside the institution all introduce additional risks, and the University must determine how to apply appropriate security to protect information.

We must respond to information and infrastructure security at multiple levels:

- Management of storage and computing capacity needs to move towards appropriately secure and auditable environments.
- Enabling technologies, (e.g., the Identity and Access Management system) need to assist in the easy and effective provisioning and de-provisioning of access and the appropriate logging of activities.
- We must continually communicate to the community the advantages of established, vetted solutions, and how to exercise good judgment when choosing between solutions.
- Policies should be clearly organized into efficient frameworks anchored in a limited set of relatively static policies. The frameworks should offer advice on business processes, office procedures, workstation and personal device security measures applicable to the types of information handled.

The following discussion paper presents an overview of the basics of a security approach, external trends, and overviews of current work and work considered for FY14-FY15.

Information Security

Summary

Information security practices should be institution-wide services which:

- Ensure the protection and safe handling of informational assets, on and off site.
- Manage and mitigate the risk of loss or exposure of sensitive data.
- Achieve compliance with expanding regulatory requirements.
- Establish the secure data handling and processing environment expected of a world-renowned institution of research and higher education.

Achievement of these goals can be accomplished through the adoption and implementation of a security framework that is:

- Based on industry accepted standards.
- Aligned with and supportive of the University's business and technology plans.
- Flexible and accommodating of the processes unique to the University.
- Responsive to the rapidly changing service demands of the community.
- Adaptable to accommodate new technologies.
- Measureable and auditable by internal and external reviewers.
- Defensible in matters of regulatory compliance and litigation.

Northwestern Themes

Build redundant, secure, maintainable services from supported, off-the-shelf components.

External Trends

Threats and vulnerabilities

- **Social Engineering.** There are persistent and targeted attacks against end users, designed to acquire a user's credentials and other personal information; the attacks are increasing in number and sophistication.
- **Malware.** As the number and presence of mobile devices has increased, so have the instances and sophistication of malware. Often customized to recognize and attack specific devices, operating systems and applications, the malware is becoming more effective and stealthier in its ability to assume ownership of personal devices and obtain personal data.
- **Specific attacks against research institutions, targeting intellectual property.** "Why develop it when we can steal it?" Exfiltration of research data is performed through compromised systems and increasingly by individuals working within the research environment that are authorized to access research data.
- **Collaborative sharing of information.** Enforcement of security and privacy measures, often required to comply with regulatory requirements, is problematic; data is purposefully made more available to a wider audience, one that is often outside the direct control and influence of the University. The challenge of data protection can be formidable as repositories can be offsite (i.e., cloud-based storage services).

- **Big Data.** The large aggregation of data raises concerns with potential abuse of privacy regulations, both in legitimate usage and instances of unauthorized access; the aggregation also makes it a more attractive and potentially high value target to spammers and data/identity thieves.
- **Consumerization of IT services and devices.** Data can quickly, sometimes unknowingly, and often uncontrollably, flow to the personal device, which has an unpredictable security environment.
- **Cloud computing services.** The needs to protect information assets, meet regulatory compliance, control data location and segregation, ensure data backup, recovery and disposal, etc. are predominant issues to be resolved; secure provisioning and execution of applications, appropriate allocation of resources, and attestation of security properties must also be addressed. Contract terms and conditions are of paramount importance where services are provided by offsite vendors.
- **Regulatory non-compliance.** The rapid adoption/deployment of new technologies can introduce challenges to regulatory compliance requirements (e.g., storage of sensitive data on less-than-secure personal devices). Special consideration is also to be afforded those instances where international law is applicable (e.g., Qatar) and differs from the requirements of U.S. regulations.

Mitigation strategies

- **Standardization of security practice with high adaptability/flexibility.** Adoption of a security framework and implementation of a streamlined policy development and approval process, providing for an effective response to rapidly changing technologies and data handling requirements.
- **Improved identity management and access control.** Processes must be improved for managing the electronic identities and credentials for all community members and affiliates. While these processes must be robust and must serve a range of security needs, basic business goals must be addressed to provision and de-provision access, afford more granular definition of personal attributes, provide for better integration of disparate systems, and thereby provide a more streamlined and secure service to the community.
- **More extensive identity and access federation.** Collaboration between institutions, and mobility of community members between institutions, should be accomplished through federated infrastructures. A federated approach determines in real time the attributes of a person through another institution's access control services. This approach results in fewer created and orphaned identities that may be vulnerable to attack.
- **Risk assessment and management.** A risk-based approach to assessing and managing threats to information assets, and supported by the security framework.
- **Enhancements to the University's Centralized Email Services.** Establish processes to better detect targeted spam (phishing) or malicious email and to "throttle back" spam email originated from compromised email accounts. (Several recent successful phishing incidents have resulted in the compromise of individual accounts and use of those accounts for spamming. This has caused the major Internet Service Providers (ISPs) to temporarily blacklist the University mail servers and stop the delivery of any NU-originated email to those ISPs.)
- **Managed environments.** The management and maintenance of user devices to reduce the vulnerabilities introduced by a privileged state of execution (administrative rights), improve maintenance (e.g., ensure timely application of patches and updates), and help ensure the upkeep of protective and detective measures (e.g., firewall, IPS/IDS, anti-malware solutions, etc.).
- **Multi-factor authentication.** An authentication measure that requires the user of a system to provide, in addition to the NetID/password, another factor (e.g., a PIN) in order to prove their identity and gain access to the system.

- **Encryption.** The process of encoding information in such a way that only authorized parties (those with the appropriate decryption “key”) can decipher the information.
- **Monitoring and analysis.** “Making sense of it all” (e.g., event and incident management solutions). Homegrown and/or commercial solutions that collect and normalize disparate data from networked devices, and permit data manipulation for purposes of analysis and assessment of security and network related events or incidents.

Northwestern Responses

Current and Upcoming Committed Projects

Acute

- **Security Framework investigation and recommendation effort.** This will determine the recommended security framework required to support all current and future security and privacy related policies, standards and activities.
- **CI Data Centers’ HIPAA/HITECH Compliance project.** The Data Centers and related defined business processes will be fully compliant with HIPAA/HITECH regulations.
- **FSM’s HIPAA/HITECH remediation effort.** Completion of this effort will bring FSM into HIPAA/HITECH compliance.
- **FSM’s Clinical and Translational Science Award (CTSA) grant – Security Plan.** Established the plan that, when executed, will bring FSM into compliance as required by the NIH CTSA grant.

Important

- **Network Access Control project – user registration.** Identify and record the users and devices attaching to the University network.
- **Cloud-based services (e.g., Box) project.** Provide a secure data repository service for use by the University that also permits a high degree of collaboration with parties external to the University.
- **Intrusion Prevention System (IPS) project.** The refresh of the current equipment/service will enhance NUIT’s capabilities for inspection and management of network traffic flow with resulting improvement to network security. (See the “IT Infrastructure” section)
- **Two-Factor Authentication project.** Establish multi-factor as a viable authentication mechanism for use where determined by business requirements (e.g., protection of Human Resources data)
- **SharePoint project.** Provide a secure and accessible data repository for the University’s internal use

Near-Term Priorities (FY14-15)

- **University-wide adoption and implementation of a Security Framework.** Upon completion, this effort will have established the foundation required to support all current and future security and privacy related policies, standards and activities.
- **Integration of systems to better ensure data integrity and secure access.** Upon completion, this effort will have established central, authoritative systems that are better secured and controlled, for use across the University and by its partners, and reduced or eliminated the need for shadow systems.
- **Establish process for assessing cloud providers,** to include a review and revision of:
 - **Service Provider Security Assessment process.** This requires refinements to queries and weighting of risks.
 - **Vendor Management.** This requires recognition of contract renewals and/or special attention (e.g., vendor handles sensitive information).

- **Contract Processing.** This requires a more streamlined workflow, assurances that all required parties are involved in a timely manner, help in determining where regulatory requirements need to be addressed, etc.
- **Enhanced support of the “remote worker.”** Recognizing and addressing the current needs and anticipating the future requirements of a more mobile “work from home” workforce (e.g., authentication enhancements; secure connectivity, processing and storage, etc.).
- **Network Access Control project – posture assessment.** Ratcheting up the functionality of the NAC application to include an examination of attaching devices for presence of operating system and application updates and patches, firewall status, presence of malware, etc. and further enabling the ability to quarantine devices found to be in a vulnerable or compromised state.

Longer-Term Priorities

- **Establish a processing environment that is compliant with FISMA requirements.** Research grants and projects can require computing services and business processes that are compliant with Federal Information Security Management Act (FISMA) requirements. FISMA compliance can be achieved by leveraging and improving upon the practice and standards implemented under HIPAA/HITECH.
- **Security Event Incident Management (SEIM) solution.** Develop a homegrown and/or acquire a commercial solution that collects and normalizes disparate data from networked devices and services, and permits data manipulation for purposes of analysis and assessment of security and network related events or incidents.

Making Room to Do More in Community

- Consolidation of distributed data processing centers into the University’s data center to reduce the distributed effort required to support these systems.
- Integration of the University’s affiliates into the NUIT authentication system (e.g., federation, establishment of appropriate Active Directory trust, etc.) leading to reduced support efforts, better access controls and improved customer satisfaction.
- Elimination of manual NetID creation in favor of a system-of-record (possibly FASIS) that would manage the lifecycle of campus visitors such as consultants and contractors.
- Establish regulatory-compliant data processing facilities and business processes to streamline and facilitate research grant requests.