

Critical Systems Strategic Research Area 2014-2017 (application for 2015)

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1. Trends and Opportunities

The Western society is increasingly relying on technology-supported data-driven decision-making practices for everything from policy development and customer engagement to critical infrastructure management and public administration. The digital world currently generates more than 1.7 billion bytes per minute (Madelin, 2013) and computational power is exploding, ushering in the age of big data. Many of the systems that support data-driven decision-making can be defined as critical to the function of society and all rely on access to these vast amounts of data and on algorithms developed to manage and process it. Thus **the demand for people skilled in big data analytics and critical thinking and capable of addressing both technical and social issues of critical systems in a data-driven world is only going to grow.**

Where in the past critical systems could be identified and defined as a diverse constellation of systems whose failure could potentially result in direct catastrophic consequences, today's critical systems are far more difficult to identify because the world is becoming every more networked, interconnected and interdependent. On the one hand this may result in more resilient systems, yet it is also far less predictable as a minor breach in one system could result in a catastrophic outcome in another. We do not aim to define what does and does not constitute a critical system. Any such definition would quickly become outdated given the rapid evolution of current technologies and an increasing interdependency between systems, networks and users. Rather we focus on an ongoing digitization of infrastructures critical to the function of democratic society and the increasing interdependency of diverse networked systems.

In their diversity these networked and interdependent systems share another underlying feature. The vast majority relies on big data and algorithms as a basis for decision-making and must confront two related but distinct problems. The first has to do with data security, addressing the vulnerabilities of networked systems that can be exploited by malicious attackers. The second and perhaps far thornier issue has to do with privacy concerns of the people whose data is collected and thus ethics of data use for decision making underlying critical functions of society. Where the first issue of data security and cyber security has received ample attention and there are many groups around the world conducting world-class research on the topic, **the second issue of algorithms, privacy and ethics in the age of big data has been considered in more piecemeal fashion and requires a concerted interdisciplinary effort to address it.** ITU is uniquely positioned to bring together scholars with relevant interests from a wide range of both technical and social disciplines who are already conducting research on this topic. **While there are many**

universities in Denmark where research is conducted on big data, privacy and ethics separately, none could produce interdisciplinary discourse at the level of depth and breadth with a focus on critical functions of society that is possible at ITU.

Thus the goal of the Critical Systems strategic research area is three-fold:

1. Develop a coherent research program around the core components of critical systems that we define as big data, algorithms, programming languages, privacy, security, and ethics, in the context of current ongoing and planned research and development of specific examples of critical systems such as voting, crypto currency or attestable privacy compliance methods.
2. Provide a truly interdisciplinary forum for knowledge exchange of current ongoing related research to enable researchers from diverse disciplines to debate, critique and take advantage of each other's expertise.
3. Support the development of an educational program on big data analytics that will be unique in its combination of technical, social and critical perspectives, producing students qualified to work in all areas of the Danish society that engage with data and analytics, combining technical skills and a sensitivity to the social implications of data-driven processes and practices.

As part of accomplishing these goals, the major effort of this strategic research area in the year 2015 will be focused on assessing our potential for developing an application for a center of excellence from Danmarks Grundforskningsfond. To this end, we request budget for faculty events for application development, support from the communications department for promotion of the critical systems strategic research area to the Danish public and administrative support for development of the application itself, should this become possible given our efforts for the development of a coherent research program. As part of the effort toward development of such an application, we will develop an application for an EU COST action around the topics of big data, privacy, security, and ethics. We have identified the majority of key stakeholders for such an action and will begin development of this application shortly. We request administrative support for this application as well.

2. Strategic Goals

The proposed strategic research area will aim to reach the following goals by 2017:

1. **Education:** Educate the next generation of IT professionals with significant technical skills in security, critical system engineering, big data analytics and an in-depth understanding of the social implication of big data and concerns around privacy and ethics with respect to critical digital infrastructures underlying the functions of the democratic society.
2. **Research:** Establish an internationally recognized center for interdisciplinary research on critical systems and the core components of big data, software engineering, algorithms, privacy, security, and ethics through a track record of external funding, high impact publications, conferences, high visibility international events, and engagement with the public and the private sector.

- 3. Collaborations:** We will establish strong connections with research units in other Danish universities that compliment ITU's expertise such as, for example, the University of Aarhus Crypto group. We will develop strong international connections with relevant research units around the world, such as for example the US Data & Society Research Institute in New York, the Center for Communication and Media Studies at the Central European University, National Institute of Standardization and Technology and Oxford Internet Institute. We will also continue ongoing collaborations with Danish and EU government bodies, contributing both to technical and policy discussions. Alongside these high-level collaborative endeavors we will support individual faculty collaborations worldwide.

3. Value Propositions

The Western society is becoming increasingly digital, relying on socio-technical systems such as physical infrastructures and networks that are evolving at an impressive speed. The basic functions of society, health, energy, communication, news production and dissemination, public opinion, social interaction and public administration are based on data collected, stored, analyzed and distributed by these socio-technical systems. Within the Critical Systems strategic area, we focus on technological aspects of how to build critical systems, as well as how to analyze them. Big data, for example, can potentially generate significant enhancements in all areas of society, but unfettered data collection and use represent very real threats to the notion of privacy as a fundamental human right held up by the European Union. While data-driven decision making practices rely on output of algorithmic analyses of big data, there are increasing concerns that machine learning algorithms based on historical data may replicate and reinforce pre-existing societal biases rather than providing impartial solutions. No matter the debates about the value of personal data and privacy, big data are here to stay and it is crucial that the ethical dilemmas around the uses of data are addressed together with technical development. As Madelin (2013) notes "user trust is key to Big Data success". However, *user trust* should be related to *system trustworthiness* and the Critical Systems strategic research area aims to address this fundamental issue through interdisciplinary research.

Information technology and society are produced together in several ways. The collective imagination of society defines innovation while technological development reconfigures social order. This relationship results in a mutual dependence and shows that as data-driven decision making becomes core to many of the functions of the western society, technological development to enable these changes must be combined with critical social science approaches in order to ensure equal and just societies of the future. For example, there is a great deal of research in explaining sociotechnical phenomena such as crowd control, user interface testing, trust development online, mediated communication and social practice, disaster response and recovery. However, this research still does not provide a good basis for how to describe ideas such as privacy, trust, risk, fear, comfort or enjoyment in terms of mathematics, which is necessary for building computational systems that can take these into account. This is in part because true interdisciplinary efforts are difficult to accomplish due to disciplinary barriers and a lack of a common language. Developing interdisciplinary discourse can be an accomplishment in and of itself and

methods for achieving this feat would be a significant contribution to research and development in Denmark and in the EU.

3.1 Strength and Weaknesses

The IT University is an ideal place in Denmark for the development of a range of research and study programs on big data analytics, algorithmic thinking, technological support for data-driven decision making, critical analysis of big data systems, privacy issues and ethical concerns because of its inherently interdisciplinary nature.

We therefore see several **strengths** in continuing the proposed research area at the ITU:

- Existing diverse internationally acclaimed research efforts on the topic are already ongoing at the ITU and thus this strategic research area brings together researchers from different disciplines who have already developed research interests on the same topic from different points of view.
- The majority of currently funded projects and applications for external funding that have been submitted in 2014 address the topics central to Critical Systems. Thus not only have the participants in this strategic area demonstrated their ability to attract external funding but they also continue to demonstrate significant commitment to the topic.
- The kind of interdisciplinary work that will be showcased through this strategic research area will fit with the external perception of ITU from industry and governmental agencies as a unique interdisciplinary educational and research institution.
- Participants in this strategic research area have previously established significant and diverse contacts worldwide with policy makers, governments, industry and research. We will leverage these networks to both promote ITU and Critical Systems and to develop substantive collaborations and partnerships.
- All participants in the strategic research area are not only already involved in the different study lines at the ITU (GBI, DIM, SWU, DDK, DMD, SDG) but also have started a university-wide conversation to develop this educational direction with the different study line heads.
- Members of this strategic research area are also involved in developing interdisciplinary and cross-cutting initiatives such as the Digital Methods lab that is a collaboration of faculty involved in Energy Futures and Critical Systems strategic research areas intended to support development of big data analytics study programs that are cross-cutting across existing study lines with provision of basic skills training to students lacking requisite skills and knowledge.
- ITU students expect to be exposed to ideas about big data analytics from different points of view and are already demanding such courses. Thus we do not have to guess whether this study direction would attract students, we already know there is significant demand.
- Research activities conducted within Critical Systems have been discussed in the press at several occasions. There is significant demand for a go-to point for the press regarding questions and comments on critical systems including cybersecurity and big data at ITU.

Alongside our significant strengths we acknowledge several **weaknesses** and ways to mitigate these:

- Despite the breadth of interdisciplinary expertise available at the ITU, we do not cover all the relevant topics. Thus we will develop partnerships and collaborations with other research units in Denmark and worldwide with relevant complimentary expertise.
- Because of its size ITU faces challenges in terms of thematic coverage but it is also important to recognize that diversity in topics of research is crucial for a dynamic research environment. While we see the topics of big data, algorithms, privacy and ethics as core to Critical Systems, we recognize that ours is but one particular lens on these areas of research. Thus Critical Systems will ensure and encourage development of connections with the two other strategic research areas at the ITU – Energy Futures and DECIDIS – as these strategic areas offer different but complementary approaches to the same topics.

4. Education

Critical Systems educational goals align with ongoing efforts across ITU to develop interdisciplinary courses that address topics relevant to the study of critical infrastructures and data-driven decision-making. Thus Critical Systems will support the development of the Critical Systems specialization in SDT as well as the big data analytics specializations and potentially even a study line, which will become the first at ITU to truly bridge between existing study-lines, engaging faculty from all corners of ITU to collaborate and develop courses that build technical and critical expertise as well as speak to each other in a coherent fashion. Such a study line would be unique in Denmark and would produce graduates to address a growing need for skills in big data handling, management and analytics as well as the need for sensitivity and knowledge to address ethical and privacy concerns.

Big data analytics is a popular theme and ITU, while well positioned to develop a unique program addressing this topic, instead has a blind spot in its current educational programs. There are many education programs focusing on big data and analytics worldwide, yet none can bring to bear the kind of interdisciplinary sensibility with both depth of expertise and breadth of points of view. This is a significant opportunity for the IT University and efforts are already underway to develop new courses, specializations and perhaps even a whole new study line on the topic.

4.1 Educational goals

- Design new courses that bridge the cap/gap? between the different study lines
- Identify courses available at other Danish universities that would compliment ITU's efforts such as potential electives dealing with legal issues and policies related to personal data in Denmark and Europe or in-depth studies of cryptography.
- Provide students with more opportunities for hands-on experience through collaborations with Danish companies and government institutions. For example

building on existing and potential collaborations with Copenhagen Kommune, Digst, or Rejsekort

- Impact curriculums for all Bachelor, Master and Kandidat study lines by offering a range of electives addressing issues of critical systems as related to critical system engineering, big data, analytics, privacy, security and ethics.

4.2 Existing course offerings

There are a number of existing courses designed and taught by Critical Systems faculty that have been deployed in Spring and Fall of 2014 and are in development for Spring 2015 by members of the critical systems strategic research area that fall under the general theme of big data, analytics, privacy and ethics. Several of these courses are collaborations with faculty from other strategic research areas, demonstrating the importance of the topics and the synergy among different research directions.

- DMD: Digital materials and Social Media (**Luca Rossi**) – Spring 2014
- DMD: Network society (**Luca Rossi & Irina Shklovski**) – Fall 2014
- SDT: Critical Systems Course (Marco Carbone, **Thomas Hildebrandt, Carsten Schürmann**) – Fall 2014
- SDT: Critical Systems Project (Marco Carbone, **Thomas Hildebrandt, Carsten Schürmann**) – Fall 2014
- DDK: Exploring Networked Culture (**Luca Rossi** with Lisbeth Klastrup) – Fall 2014
- GBI: The data revolution (**Lars Rune Christensen**) – Spring 2015
- SWU: Reflections on IT (**Judith Simon** with Vasiliki Baka, Martin Skovberg Jensen, Christopher Gad) – Spring 2015
- GBI: Philosophy of Science and Technology (**Judith Simon** with Vasiliki Baka, Martin Skovberg Jensen, **Christopher Gad**) – Spring 2015
- DMD: Philosophy of Science (**Judith Simon** with Vasiliki Baka, Martin Skovberg Jensen, **Christopher Gad**) – Spring 2015
- DIM: Digital Management, Accountability & Governance (**Steffen Dalsgaard, Lars Rune Christensen**)
- DIM: Big Data – technical issues, ethical concerns (**Irina Shklovski** with Philippe Bonnet) – Spring 2015
- SDT: System Architecture and Security (**Søren Dubois**) – Spring 2015

4.3 Tactics

Activities in 2014:

Rossi, Shklovski, Hildebrandt and Schürmann taught several courses on topics related to critical systems. Experience from these efforts will be shared with faculty developing courses for 2015 in order to ensure continuity and to learn on each other's mistakes given the difficulty of teaching highly interdisciplinary topics to students in current study lines.

Plans for 2015:

Many of the Critical Systems participants already teach relevant courses and are working to develop connections between courses across study lines. We intend to ensure that at least

one course per semester that addresses topics relevant to critical systems will be taught on each study line. These courses will provide the basis for the development of crosscutting specializations on big data in cooperation with faculty from Energy Futures and DECIDIS in 2016.

One of the issues with teaching courses crosscutting across study programs is the significant difference in backgrounds for the students. To mitigate these issues several faculty from Critical Systems will be involved with the Digital Methods Lab, offering workshops on rudimentary technical and theoretical topics to enable students to catch up on skills and knowledge that they may lack. We intend to offer two to three workshops per semester on social network analysis, data visualization, and collection and analysis of social media data. We will draw on internal expertise as well as the expertise of visiting scholars.

Alongside this course-work we will encourage students to develop their big data-related projects into masters thesis work under our supervision. Given the existing interest in this area, we envision at least 12-15 masters theses supervised by fall 2016. Additionally, we plan to supervise PhD theses on critical systems and big data-related topics.

We have identified several synergistic educational programs in Data Science and Critical Data Science currently starting up at the London School of Economics and Goldsmiths University in the UK and have made contact with the heads of these programs to develop potential partnerships and exchange of expertise in conducting such educational programs.

5. Research

The proposed strategic research is timely. Systems that rely on big data and networked capabilities now underlie every critical function of society. Consider, for example, the protection of privacy in the age of social networks and the internet of things, the legal implications of distributing copyrighted materials across digital networks, the impact on work processes in the public sector, the modernization of democracy using information technology. The societal importance of the questions that the proposed strategic research area will work towards is immense, and what is considered a challenge today may turn into a significant problem tomorrow. What sets the proposed strategic research area apart from the other efforts is its focus on the connection between the technical and the social, taking a holistic point of view, working on the synergistic effects that arise when disciplines meet – herein lies an opportunity to do something novel and unique.

Recognizing excellence in research that is already ongoing at ITU, the goal of Critical Systems is two-fold.

First, we intend to use the strategic research area as a platform for providing interdisciplinary context for mono-disciplinary research projects without imposing undue burden on the involved researchers. We will work to develop and support interdisciplinary discourse through a series of internal discussions punctuated by larger events with interdisciplinary rosters of invited speakers. We have already planned three such events for the 2014-2015 academic year (see below).

Second, we will conduct information and brainstorming sessions for participating faculty interested in developing new funding applications relevant to the research directions under Critical Systems, providing mentorship and advice from experienced grant applicants. The goal of these activities is to develop a coherent direction of research and a community of researchers that can facilitate interdisciplinary collaborations.

The following ongoing activities will be part of the strategic research area:

- Big data and research ethics –Rachel Douglas Jones & Judith Simon
- Big data and value – Steffen Dalsgaard & Lars Rune Christensen
- Creepy technologies – Irina Shklovski
- Crypto-currency – Roman Beck & Steffen Dalsgaard
- Data leakage and security – Wakowski & Shklovski
- Electoral technologies of the future – DemTech – Carsten Schurmann
- Epistemology & ethics of big data practices – Judith Simon
- Interactions with data – Irina Shklovski
- Management of information breaches & critical systems – Roman Beck
- Multi-level social network analysis and data mining of publicly available social data – Luca Rossi
- Process and Social Data Mining for Business Intelligence Process Discovery – Thomas Hildebrandt
- Redefining notions of privacy for the world of big data – Irina Shklovski & Luca Rossi
- Security and compliance verification and monitoring for business processes – Thomas Hildebrandt
- Trust, knowledge & computing – Judith Simon

5.1 Activities in 2014:

Our major activity in 2014 was assessing the viability of critical systems as a strategic research area and developing a consistent set of topics that helped define the goals of this research effort and faculty that are interested in participating. Two major accomplishments were: bringing together faculty from different corners of ITU for several productive interdisciplinary conversations that germinated potential interdisciplinary research projects and leading a concerted effort toward development of big data analytics education at ITU. Alongside these accomplishments we have also produced several other achievements:

Internal ITU faculty workshops

Carsten Schürmann conducted a workshop at March 31, 2014 with 6 faculty in attendance working on developing synergistic discourse around Critical Systems. Jesper Bengtson hired an undergraduate student to build a verified infrastructure for concurrent programming.

External activities

Carsten Schürmann organized a session at ESOF 2014 in Copenhagen on democracy in the digital age. Carsten Schürmann was invited to the NemID visionarium in 2014 and together with Thomas Hildebrandt, he attended meetings at the ministry for education and research regarding Denmark's cyber security strategy.

Grants submitted (to name just a few):

EU Horizon 2020 FET Open:

PRIMULA: Understanding Privacy in the Age of Multiple Networks (Shklovski & Rossi)

APRICOT: Attestable Privacy Compliance for an Inclusive Trustable Online Society (Wasowski & Shklovski)

DFF FKK:

Speaking into the system: Big data and meta-communication in digital media (Shklovski)

Masters theses and projects supervised (a few examples):

Jesper Borgstrup: - masters thesis - This thesis proposes a protocol to conduct anonymous, trustless, decentralized elections over the internet. Only registered voters can vote, multiple votes from the same voter are easily detected and discarded, and it is infeasible to determine the identity behind a given vote with a better probability than random guessing. The voting protocol builds on top of a decentralized deadline consensus protocol which can form a consensus about which messages have been sent before a specific deadline. This consensus protocol can also be used to suit other purposes such as contests, auctions and applications in a decentralized manner. The protocols use the Bitmessage protocol for communication. Bitcoin, blockchain-technology and Invertible Bloom Lookup Tables are used for defining deadlines and timestamping of messages. Linkable Ring Signatures provide a signature scheme suitable for signing votes. A proof-of-concept client has been developed and implemented, where one can create and run elections with a basic ballot format.

Søren Erritzøe Nielsen: - masters thesis - This thesis considers what types of information people think of as "private" and in what circumstances. This is a necessary first step to understanding how to design technologies that can gracefully handle and protect personal information.

Hans Peter Muema Loessl: Creepiness in Smart Technologies – semester project.

This project addresses issues around personal data leakage and how people perceive, understand and explain how they manage their personal data on their smartphones.

Several masters thesis projects are under supervision currently on process and data mining.

5.2 Plans for 2015:

Internal ITU meetings and workshops

We plan monthly internal ITU discussion meetings for faculty and students interested in topics related to Critical Systems. The purpose of these discussion meetings will be two fold. First, these meetings will provide an environment for bottom up processes with the goal of crystallizing the set of ideas and research directions that will define Critical Systems strategic research area at the ITU. Second, these meetings will allow faculty from different corners of ITU to meet and discuss relevant topics, potentially developing ideas for collaborative projects and grant applications.

Grant writing:

We plan several ambitious grant proposals and request budget assistance for development of competitive applications to Danish Innovation fund, EU Horizon 2020 calls and DFF. At the moment, several faculty (Shklovski & Rossi) are involved in writing applications for EU Opstart money to fund development of two EU grant proposals. We also request budgetary support for these activities as part of Critical Systems as grant ideas can be developed after the Opstart deadlines and, given the popularity of the Opstart programme there is a possibility that some of our applications will not be funded. We are also working on an international training network application (Marie Curie, ITN) (Schürmann) on democracy in the digital age, as well as several other Denmark and EU applications on big data and business processes (Hildebrandt)

As part of the preparation for development of joint projects, we envision three-four small pilot research projects run as "proof of concept" throughout the year. We request minimal funding for resources and research assistants for this purpose.

Masters projects and PhD theses supervision:

We intend to promote Critical Systems related topics to attract masters' thesis students to conduct research and to write theses on relevant topics. Judith Simon is supervising a PhD thesis on the governance of big data practices. Irina Shklovski is supervising a PhD thesis on the management, protection and disclosure of personal health data in Denmark.

6. Broader Impact

The critical systems strategic research area will build alliances with governments as well as nongovernmental organizations in order to enable a productive knowledge exchange between policy and research and to support policy development from a combined social and technical perspective. Note that, while we do not list reputation as an explicit goal for this strategic area, the indicators that we define as criteria for success for the strategic goals mentioned above largely overlap with the indicators defined as reputation indicators for ITU research strategy.

Creating value for Denmark is one of the main goals of the proposed strategic research area. The long term impact of this research area is both local and global: To define a research area on critical systems from a socio-technical perspective – not only scientifically in terms of publications and systems released, but also to make a difference in public policy in Denmark and other parts of the world, that are struggling with the introduction of critical systems and with balancing the benefits of big data and the threats to privacy and personal data.

Finally, the Critical Systems strategic research area provides a platform for interdisciplinary research and collaboration through interaction of researchers working with formal methods, software engineering, program verification, science and technology studies, sociology, human computer interaction, communication studies, economics and philosophy. Providing an environment where research can develop an understanding of different disciplines, languages, methodologies and epistemologies can strengthen research

collaboration as well as broaden perspectives on individual research agendas within disciplines.

6.1 Activities in 2014:

We designed a logo and developed a rudimentary web presence for the strategic research area at <http://criticalsystems.itu.dk>

We have developed a relationship with Professor Andrew Clement from the Information Sciences department at the University of Toronto. Professor Clement is involved in several significant projects around information security and privacy. We request budgetary support to fund Professor Clement visiting ITU for a week twice a year for advising on grant development, discussion of ideas and project development.

We are currently in discussion with the Data & Society research institute in New York around potential collaborations.

To start the process of interdisciplinary discourse and development of international connections, we have planned events with invited speakers in 2014-2015 on core topics for Critical Systems. These events include a public debate and an invitation-only smaller idea-development and exchange workshop.

In 2014 we have organized two very well attended events under the banner of Critical Systems. Both events generated lively discussions and developed relationships with international faculty.

1. Big Data and Research Ethics – conducted in November 2014.
We invited a speaker with international reputation who was responsible for a recent publication that brought issues of big data and research ethics to the popular conversation. Professor Jeff Hancock from Cornell University conducted an interdisciplinary debate on issues of big data and ethics with ITU's professor Rasmus Pagh (theoretical computer science) and ITU's assistant professor Rachel Douglas Jones (anthropology). The debate was conducted as an open event with audience comprising faculty and students from ITU, University of Copenhagen, Copenhagen Business School, KTH Sweden and Malmo University. The debate involved audience and presenters and went on for nearly three hours of productive and engaging conversation, showcasing the potential for truly interdisciplinary events at the ITU.
2. A public lecture by Andrew Clement (University of Toronto) "Internet Surveillance after Snowden: Mapping personal communication through NSA" – the lecture was a last minute addition to public events in 2014. However, even with very short notice the lecture was so well attended there was standing room only in the venue allocated to the event.

6.2 Plans for 2015:

We request budget for further development of a website that would allow public participation and communication. Further, we intend to engage with the communication department in order to publicize the research and educational opportunities provided by critical systems and to enter into public debate. We request support for these activities from the management.

Many of the faculty involved with the Critical Systems strategic research area are highly visible and are frequently invited to speak on the topics of big data, democratizing technologies, privacy and ethics already. For example, Irina Shklovski has been invited to give a keynote at the *Reconsidering Humanity: Big Data, the Scientific Method, and the Images of Humans* symposium conducted at the University of Gothenburg, Sweden in June 2015. In 2014 Judith Simon gave several invited lectures and keynotes on the epistemology and ethics of big data in Germany, Greece, Canada, Sweden and Norway and has further invited talks upcoming in 2015. We will continue these activities and publicize our involvement with Critical Systems.

The basic goals of Critical Systems for 2015 involve development of the Critical Systems identity and reputation in Denmark as an important resource for concerns around big data, algorithms, security, privacy and ethics with respect to critical infrastructure development. Further, our goal is to provide the necessary resources to faculty for development of successful funding applications for both Danish and EU funding opportunities. We see 2015 as a year to invest in developing a funding base for Critical Systems and for achieving a truly interdisciplinary discourse across the ITU.

6.3 Tactics

We will actively pursue new opportunities as well as further strengthen and develop existing connections and collaborations. Using the proposers' networks that include IFES, UNDP, DIGST, The Danish trade council and the Carter Center we will develop research and advisory connections in post-conflict countries.

Two of the members of Critical Systems, Judith Simon and Irina Shklovski, are editors for the new Sage journal *Big Data and Society* and this involvement further raises the legitimacy and status of the strategic research area and of ITU in the broader academic community.

As part of our efforts to engage external stakeholders and the general public we will continue to organize public events. The following events are planned for 2015:

1. Privacy concerns in social network platforms, open data and Internet governance – planned for February 2015.

Given recent controversies around Facebook's data mismanagement and Danish national controversies around discoveries of misuse of health data, considerations of privacy and big data are key. Professor Alessandro Acquisti from Carnegie Mellon University is a world authority on economics of privacy in social networks. Assistant Professor Alison Powell from the London School of Economics conducts research on

digital media policy, advocacy and open data culture. Professor Acquisti and Dr. Powell will be joined by ITU's Irina Shklovski and Judith Simon for an interdisciplinary debate. Both Alessandro Acquisti and Alison Powell have indicated interest in participating.

2. Democratizing technologies – planned for Spring 2015 potentially in collaboration with DECIDIS.

While networked technologies have commonly been hailed as a democratizing force, there have been many conflicting examples from difficulties with security and trust in electoral technologies to surveillance conducted by democratic and authoritarian governments on citizens of their own and other countries. Professor Philip Howard from the University of Washington in the US and Central European University in Budapest is the world authority on the impact of digital media on political life around the world, and conducts projects on digital activism, global information access, and political Islam. His book "Democracy's Fourth Wave" with Oxford University Press will be published in February 2015. Professor Howard will be joined by ITU's Carsten Schurmann for a discussion of social and technical issues around democracy, technology and electoral realities. Professor Howard has expressed interest in participating.

3. Bitcoin workshop – planned for late spring-summer 2015.

Bitcoin has achieved a widespread success and become a popular alternative payment system that uses and maintains a digital currency. Its protocol has been modified and extended by a large community of developers and researchers, often producing alternate protocols which now coexist and compete with Bitcoin in a larger ecosystem known as "cryptocurrencies". There has been a lot of media coverage on cryptocurrencies, related to their exciting possibilities but also its challenges and controversial implications. For this reason, the IT University of Copenhagen, in Denmark, is hosting a "Workshop on Cryptographic Currencies: Opportunities and Risks". The workshop will consist of a panel discussion, where we expect to discuss the global impact of cryptocurrencies, and explore the effects of such decentralised currencies. Our aim for this workshop is to bring together interested researchers and members of industry, working on technology and finance, but also key stakeholders from the media and politicians, to debate divergent perspectives regarding the impact of cryptocurrencies from a technical and socio-economic perspective. This workshop is an opportunity to share your thoughts, experience and concerns on the subject.

4. Distinguished lectures – throughout the spring and fall of 2015 we will hold a series of distinguished lectures by speakers who are visiting Copenhagen or whom we invite specifically for networking and presenting a lecture. One such opportunity will be through utilizing our advisory board distinguished visitors. We have also received an expression of interest from professor Paul Dourish (UCI) who will be a Velux visiting professor in the fall of 2015 provided the ITU application is approved by Velux. Finally, we will use the available funds strategically to invite speakers that can further the mission of critical systems and develop strong connections with important players in the field outside of ITU.

The interdisciplinary open events described above are intended to encourage discussions across the university. Along with the public debates described above we also plan a lecture series of four lectures conducted by ITU faculty and guests on relevant topics. We request

budget for bringing to the ITU scholars that will engage in the public debates and for provision of refreshments to audience from across Copenhagen and beyond.

7. Leadership

Three faculty members – Carsten Schurmann, Irina Shklovski and Judith Simon – have volunteered to serve on the steering committee of the Critical Systems strategic research area and are responsible for monitoring budget, organizing events and supporting an ongoing internal interdisciplinary conversation.

We intend to involve an advisory board to help develop a broader worldwide network and to receive external disciplinary and industry input and oversight. The role of these advisors will be to guide the development of this strategic research area, to provide input and review on major deliverables, to assist in the preparation of publications and demonstrations, and to participate in annual reviews of work. Currently our advisory board is composed of Professor Andrew Clement (University of Toronto) and Professor Alex Halderman (University of Michigan). Both have agreed to travel to Copenhagen for annual meetings. We intend to expand the advisory board to four members in 2015.

8. Relationship to overall ITU strategy

The proposed research area aligns well with the overall strategy of the ITU. Based on the track record of the members of SSS, TCS, Inter-section and Culture & Games, the proposed strategic area will deliver world-class research. Based on existing projects and interactions it is clear that this proposed strategic research area will have impact on the greater Copenhagen area specifically and on Denmark as a whole through consultations on policy and relationships with industry and non-governmental organizations. Finally, we believe that it is the mission of this university, a unique opportunity that sets ITU apart from other universities in Denmark, to educate new generations of IT professionals and prepare them for leadership positions in industry, public service and academia.

The proposed strategic research area *Critical Systems* is central to the mission of the IT University of Copenhagen. Future generations of ITU graduates will be faced with new challenges that result from the continuing deployment of cyber-social systems all of Denmark, Europe, and worldwide. The proposed research area has the potential to provide teaching content for undergraduate, graduate, and PhD level courses and thus to set the IT University of Copenhagen apart from other Danish competing universities.