Slide 1: Introduction

Good afternoon. Welcome to this webinar on the joint NSF-Intel solicitation on Information-Centric Networking in Wireless Edge Networks. My name is Ken Calvert, and I'm the Division Director for the Computer and Network Systems division in the CISE Directorate at NSF.

A few housekeeping guidelines before we get started: The webinar is about 90 minutes long. The presentation will be approximately 45 minutes, with the remainder of the time dedicated to the question-and-answer session from the participants. Please save your questions until the end of the presentation. We have representatives from both NSF and Intel participating in the call today, and both are available to answer your questions. The Q&A session will be guided by the moderator, so kindly follow the instructions from the moderator for the Q&A session. We have a large number of participants on the call today, so there can some delays before you get an opportunity to ask a question. A summary list of the questions and answers will be published in a FAQ within the next three weeks on the program website noted in this slide.

Slide 2: Agenda

I have with me here at NSF Thyaga Nandagopal and Darleen Fisher from CISE/CNS. From the Intel side, we have David Ott, and Jeff Foerster.

As far as the agenda, we'll first provide some context from both NSF and Intel. We'll then go over the challenge that we seek to address in this solicitation. After that we'll address the scope, requirements and the review process for this joint solicitation. The Q&A session will happen right after that.

As a bit of background: the Internet protocol architecture (i.e., TCP/IP) has been amazingly successful, and has changed our world. But the protocols we use today were designed more than three decades ago, and have been showing their age for some time now. One of the biggest challenges in networking today is how to move toward a network architecture better suited to today's world, *while continuing to rely on the existing Internet* -- a challenge that's been compared to changing the tires on a moving car.

Obviously folks have been thinking about this problem for some time. NSF started to rethink Internet architecture requirements about 10 years ago, with the Future Internet Design -- FIND -- program. This led to a much bigger, clean-slate challenge in the form of the Future Internet Architecture (FIA) program. From the projects funded through FIA, NSF further funded three candidate architectures to develop practical use cases with shareable, open-source implementations. These projects are nearing completion at this time. The links to each of these programs can be found at http://www.nets-fia.net.

Through this new program, NSF and Intel are challenging the research community to investigate the application of information-centric architectures—such as those developed through FIA and elsewhere—in certain constrained circumstances, and specifically in high-performance, low-latency wireless edge networks. The idea is to explore the value of this new network paradigm—which focuses on content objects as the primary service abstraction, rather than hosts or channels—for achieving scale and performance that would be very difficult to obtain with legacy protocols, even in an isolated region.

Today, Intel plays a key role in delivering and consuming content everywhere, and we greatly value them as a vital partner in this effort. We appreciate their willingness to work with NSF.

On that note, I'd like to introduce David Ott, who will provide Intel's perspective on this partnership.

Slide 3: Intel Partnership

Intel is pleased to collaborate with the NSF in co-sponsoring university research in areas of strong mutual interest. This is the third program of its kind. The first two programs were announced in 2014, the "NSF/Intel Partnership on Cyber-Physical Systems Security and Privacy" or "CPS-Security", and the "NSF/Intel Partnership on Visual and Experiential Computing" or "VEC".

Intel appreciates the important role of university research in exploring new technologies and solutions to forward-looking technical challenges. Key findings are of interest to Intel and the broader industry ecosystem as we work together to understand future technology directions and the boundaries of what is possible. University research can be particularly important in understanding new technology requirements, in exploring the fundamental tradeoffs in complex system design, and in developing brand new approaches that can be built upon by the industry, including companies like Intel.

Intel views this particular NSF collaboration as a way to augment a number of other Intel-funded university research programs in 5G, Software Defined Networks, and other related areas.

Slide 4: ICN-WEN Vision--Background

What drove NSF and Intel to issue this solicitation?

We are interested in developing next-generation wireless networks, building upon and extending 5G to offer peak bit rates of tens of gigabits per second at the radio layer, and latencies of less than a millisecond across the wireless edge. Our goal is to enable autonomous vehicles, industrial robotics, tactile Internet applications, virtual and augmented reality, and dense Internet of Things (IoT) deployments.

These cutting-edge applications require fast ***information response time*** that is invariant as a function of the bandwidth demanded, users and devices supported, and data generated. While low-latency wireless communication will be a feature of emerging 5G radio networks, it is only one component of the total information response time requirement, which also considers the availability, placement, and real-time management of data. At the same time, to ensure widespread adoption, these applications need to support intrinsic security, seamless mobility and discovery of devices and content, as well as scalable content distribution.

Slide 5: ICN and the Wireless Edge

Information-centric networks promise efficient content delivery, mobility, scalability and security for content identification and distribution. At the same time, future 5G networks will promise data rates of multi gigabits per second and low latencies, while scaling up significantly the number of devices that can be supported. Emerging applications such as tactile Internet and IoT need all, or at least a sizeable subset, of these features.

Another notable feature of these forward-looking applications is that in order to reduce latency and bandwidth requirements, content will need to be either localized or pushed to the edge of the network. While legacy deployments make clean-slate global network architectures challenging, edge wireless networks provide an opportunity to deploy 'clean-slate' approaches as self-contained information 'islands'. The question that we wish to explore, then, is, “Can we make ICN work in the wireless edge?”

To summarize, what we are looking for in this solicitation are innovative approaches that apply ICN principles to wireless networks in order to meet the performance and security demands of future applications.

Now I'll turn it over to Jeff Foerster, who will describe the research challenges to be addressed in this solicitation.

Slide 6: ICN-WEN Challenge

This solicitation seeks to *augment* existing efforts on 5G wireless research to create an information plane that addresses discovery, movement and management of data features, for example, which are also critical towards enabling fast information response time and scalability required for beyond 5G applications. Therefore we are challenging the community to come up with a co-design of ICN and wireless networks, as ICN approaches the promise to deliver the required information plane features currently not addressed by existing 5G wireless research.

In particular, we are looking for how ICN could be integrated and co-optimized with a wireless network and address fundamental challenges involving:

1. Discovery, movement, transport, reliability, & management of data
2. Naming, caching, and storage of content & distributed processing
3. Protection of information within a network involving both privacy and security
4. Device power consumption, and device & network heterogeneity recognizing that 5G networks will support numerous wireless technologies and types of devices.
5. And finally Network latency and large scale scalability

For this kind of research to be impactful, it will be important to demonstrate and quantify the benefits of this new architecture via simulations, emulations, and testbeds.

And then, finally, help transition the ideas into practice by evaluating realistic deployment scenarios and understanding practical implementation approaches.

Slide 7: ICN-WEN Goals

The goal of this program is to enable future Beyond-5G applications with a specific focus on two main applications.

First focus is on low-latency applications, including the tactile internet, autonomous driving, industrial robotic control, and augmented and virtual reality applications.

The second focus is on Massive IoT deployments, including smart buildings, smart cities, agriculture, and environmental monitoring applications.

We believe these two main applications will stress the ICN and wireless network design in terms of latency, performance, and scalability to really help determine the potential value ICN could bring to wireless networks.

We narrowed the scope of the program to only focus on deployment of ICN at the edge of the network to help constrain the scope and geographical boundaries to be addressed, as well as removing any requirements for backward compatibility with existing internet architectures and protocols. However, it's still important to take into account realistic wireless network models to ensure the ICN principles can work in a realistic deployment, which would include mobility, highly varying error rates and throughputs, potential for lost links, and battery constrained devices.

Towards these goals, we have identified three main research dimensions, which must be addressed:

First, research should be focused on wireless device endpoints, which deals with, for example, the integration of ICN with the wireless stack, device power efficiency, mobility, device management and handovers, and device heterogeneity.

Second, research should look into the wireless network infrastructure and architecture, including, for example, joint optimization of the ICN and wireless architecture, end-to-end latency optimization, programmability, distributed computation and storage, network management, and reliability.

Third, research should include a focus on information security and data privacy, including, for example, ICN information plane security, device and data security, security configuration and management, and attack detection.

Finally, to test the effectiveness of a given approach to ICN and wireless networks, it will be important to have an element of prototyping and demonstration of at least one of the Beyond 5G applications discussed, either highlighting the ultra-low latency capability or the Massive IoT deployment scenario. Proposals that successfully do both may have competitive advantage. As is normal practice, this would be done though a combination of simulators, emulation environments, and real-world test infrastructure as available.

Now I'll hand it back over to Thyaga, to go over some details of the solicitation.

Slide 8: ICN-WEN

Some key points to remember:

First, the program solicitation is NSF 16-586, which is hyper-linked on the slide and you can easily find with a web search. It is also posted on the CISE website and on the CNS webpage.

Second, the proposal has a two-stage application process. Letters of Intent are required, and are due before 5pm local time on September 19, 2016. The full proposal deadline is 5:00 your local time on November 21, 2016. Proposals without an associated letter of intent will not be accepted.

NSF and Intel together expect to award approximately 2 - 3 projects. Each project may request up to 3 million dollars over 3 years.

We expect the awards to be made early spring 2017.

Slide 9: ICN-WEN Solicitation and Review

We are now going to talk about the solicitation, its requirements, thoughts about team composition, and key proposal sections and what we expect to see in each section. We will then cover the review and award selection process and we will end the webinar with Questions and Answers.

Slide 10: Who can submit

This solicitation restricts submissions to US academic institutions.

US universities and 2- and 4- year colleges including community colleges may submit one or more proposals.

An US institution, in this case, is one that is accredited within the US and has a campus in the US that acts on behalf of its faculty members.

Sub-awardee institutions have the same restrictions.

Slide 11: ICN-WEN Personnel Requirements

An individual may participate as PI, co-PI, or senior personnel in **no more than one proposal** submitted in response to this solicitation.

If any individual is found to be on more than one proposal, then the proposal with the earliest submission date will be accepted and all others will be returned without review.

Make sure that individuals on your team have consented to participate on a project and are not listed on another proposal. Remember this includes senior personnel as well.

We are looking for manageable-sized teams made up of individuals with demonstrable expertise that is needed to successfully conduct the research.

The solicitation requires that the proposal justify the inclusion of each team member and show how this person will contribute to the overall vision of the program and the specific goals of the project.

Slide 12: ICN-WEN Letter of Intent

Many of you may not be familiar with the two-stage application process that requires submissions of letter of intent, also called LOI.

The purpose of the LOI is to inform NSF about potential teams that will be applying to the program. This helps with the process of planning panels and identifying reviewers.

For each project, only one LOI must be submitted. If your project is a collaborative project with multiple institutions, only the lead institution should submit the LOI.

The LOI should not exceed 2 pages. It should contain three elements:

(1) A synopsis of the project,

(2) A clear description of how the proposed research will address the three dimensions that the solicitation seeks to target, and

(3) A listing of all team members (for collaborative proposals, list across multiple institutions), and their relevant expertise to help on this project.

Please note that you can change the team composition between the submission of the LOI and the full proposal. The only invariant is the identity of the Institution submitting the LOI and the lead PI.

Slide 13: ICN-WEN Full Proposal

Here are the requirements for preparing the full proposal:

The title should start with the keyword ICN-WEN

Instead of the default 15 pages for the project description, this solicitation allows for up to 20 pages. Use this wisely.

The list of supplementary documents needed is noted here, and we will cover it next. Please also note that all NSF proposals require you to submit a list of collaborators as a single-copy document. In case of collaborating institutions, the lead institution must do this. The purpose of this is to help us identify conflicts of interest, so for co-author conflicts, include only those with paper publication date within the last 4 years of the solicitation deadline.

Slide 14: ICN-WEN Section Requirements: Project Description (up to 20 pages)

In the project description, there are very specific topics that should be addressed.

The purpose of listing these topics is to make sure you clearly describe the proposed research and how it addresses the goals of the solicitation, how you plan to validate your research, how you will manage the project, the education and outreach activities, and how you might move this research into practice beyond publishing academic papers. We want these projects to have real-world impact.

Most importantly we want to see a clear statement about how the outcomes of your proposed work, focusing on information-centric networks in the wireless context, will support the application types that

the solicitation is targeting, while addressing the three dimensions of device endpoints, architecture and security with data privacy.

We expect that you might divide the proposed research into topics or component. We would like to see how the components synergistically work together to advance the goals of the solicitation.

We expect to see a validation plan that includes a combination of simulation, development of prototype systems and experimentation using the prototypes.

The solicitation further calls for a Gantt chart that lays out the major tasks, milestones and interdependencies among the tasks. Please note that the solicitation also calls for a management plan as a supplementary document, which we will discuss later in the webinar. We mention it now, because you should consider including in the Gantt chart a way to indicate which team member or members are responsible for each task.

Slide 15: ICN-WEN Section Requirements: Project Description (continued)

Broader Impact and the education of the next generation of researchers, scientists, and information technology workers are always of key value to the National Science Foundation. In your proposal, you should show how your work will advance the field and indicate discuss your plans to integrate this research into education. This section should be "actionable" in the future and not just include past achievements or vague aspirations, but include clear cut plans and budgeted resources for such plans. We note that you may request REU (Research Experience for Undergraduates) funds in the budget for up to $16K for the first year to support two US Citizen undergraduate students for each institution involved in the project. REU funds do not count against the $3M budget limit.

If your project involves more than one institution, you should provide the rationale for including them and describe how you will ensure effective collaboration. You should not think that once you are awarded that each team member is entitled to do, as individuals, "good" research in the topic area. These awards are meant to be projects in which team members actively collaborate to build a working system.

Slide 16: ICN-WEN Section Requirements: Collaboration Plan (up to 2 pages)

A Collaboration Plan is expected for all proposals that include more than one PI, which given the nature of the call, we expect will be all submitted proposals.

You should include a description of the roles of all of the participants, how the project will be managed across all investigators, institutions, and disciplines, and coordination mechanisms. The budget should include support for collaboration and project management.

Slide 17: ICN-WEN Section Requirements: Postdoctoral Research Mentoring Plan (1 page)

If a project includes funding for a postdoc, then a postdoc mentoring plan is required and is uploaded as a separate document. CRA has a resource page, hyper-linked on the slide, with best mentoring practices for you to consider.

Slide 18: ICN-WEN Section Requirements: Data Management Plan (up to 2 pages)

NSF requires a Data Management Plan for all projects. There is a hyper-link on the slide to CISE guidance on this topic.

You should describe how you plan to share and disseminate data and research results and adhere to NSF policy concerning intellectual property.

This solicitation specifically requires that software be offered with as open source under certain types of licenses that are equivalent to BSD/Apache 2.0.

You should read the solicitation for more information. In addition, the plans should talk about supporting a website with current and up-to-date information on the project progress.

Slide 19: ICN-WEN: Additional Supplementary Documents

You may include letters of collaboration pledging, for example, data or access to resources or facilities. Letters of collaboration must follow a specific format noted in the NSF Grant Proposal Guide.

You may NOT include letters of general support for the project or its expected outcomes. Proposals with such letters of support may be returned without review. No other supplementary documentation is required.

Slide 20: Additional ICN-WEN Personnel Suggestions

In terms of personnel other than the investigators, we expect to see support for graduate students.

You may also request support for software engineers or other necessary technical personnel, as well as for postdocs, as long as it is justified appropriately.

Slide 21: ICN-WEN Review Process

The review process for proposals received in response to this solicitations is as follows. Proposals will be reviewed independently by Intel and NSF. Intel will conduct an internal review of the proposals.

At NSF, proposals will be reviewed by a merit review panel. The program director may request additional ad hoc reviews for a project as appropriate. The proposals will be reviewed according to the NSF-standard Intellectual Merit and Broader Impact review criteria. In addition the reviewers will be asked to consider the solicitation-specific review criteria found in the solicitation. NSF will conduct the

panels; Intel team members will attend the panels as observers. NSF and Intel will then meet to discuss the proposals and decide whether to have a reverse site visit for the top rated projects, whereby individual teams are called upon to answer concerns raised by the reviews, NSF program directors or Intel partners.

NSF and Intel will jointly make the final funding decisions.

Slide 22: ICN-WEN: Solicitation-specific Review Criteria

The solicitation-specific review criteria include the extent to which projects will innovate along the three dimensions of the project, the potential for non-incremental advances in the field, and relevance to the target application types.

We do not want to see individual research topics "stapled together", but a coherent whole that is more than the sum of its parts.

The other review criteria will be the effectiveness of the proposed collaboration, as well as the cost-effectiveness of the proposed solutions.

Slide 23: ICN-WEN: Funding model

Projects will be jointly funded by NSF and Intel through separate funding instruments.

NSF will make grants.

Intel will make Intel agreements.

Projects may receive supplements from either NSF or Intel.

Slide 24: ICN-WEN: Program management

NSF and Intel will work together to jointly manage the projects while following the guidelines and regulations governing each party. Each will designate a Program Director for each award and these program directors will jointly manage the project.

We expect that there will be Annual on-site reviews conducted jointly by NSF and Intel. We envision an annual PI meeting for the awardees under this solicitation. Each project should budget for appropriate travel to permit team members to travel to the PI meetings. The annual on-site reviews might be conducted in conjunction with the PI meetings.

Intel may choose to be active participant in the projects.

For example, the Intel Program Director may become a member of the NSF/Intel Partnership Project Management Team.

Intel may also invite academic faculty and students to visit Intel and may visit research institutions upon request.

Slide 25: ICN-WEN and National Priorities

The ICN-WEN solicitation aligns nicely with the National Priorities as designated by the White House by supporting high-risk, potentially high payoff research and education. We hope that projects will be transform how we think about and design secure, complex engineered systems, specifically by creating trustworthy networks that can meet the information needs of the 21st century.

Slide 26: Reminder: Deadlines

Remember that the LOI for proposals are due by September 19th, and the full proposals are due by November 21st, 2016. We hope that this 4-month period to prepare a full proposal gives you the opportunity to put together a high-powered teams and a well-crafted research agenda to unleash the power of wireless-enabled Information-Centric Networks.

Slide 27: FAQ's

We will now open up the floor for questions. We will compile the questions and answers into a Frequently Asked Questions or FAQ list and post it on the webpage for this webinar within the next four weeks.

Please note that the questions answered today are informal and only serve to clarify. The solicitation is the official final word. The Formal FAQ to be posted on the program site is also only an advisory document, and is not binding.

Slide 28: FAQ's (continued)

One question that may be on your mind right now is whether the Letter of Intent serves as a screening process and if there will be any kind of feedback from NSF or Intel?

LoI serves to inform NSF and Intel on what projects are being devised by the community in response, with the understanding that not all of them might materialize into full proposals. Intel and/or NSF can optionally choose to respond to any of the specific teams with queries on the contents on the LoI. We stress that **PIs should not expect any response from NSF**. An official **acknowledgment** of the receipt of the LoI will be sent out by October 3, 2016.

Slide 29: FAQ's (continued)

The internal review criteria for Intel is covered within the solicitation, excerpted here.

Another question asked was about potential collaborations with researchers in foreign countries. NSF has agreements with multiple countries that encourage joint proposals between researchers in the US and the other countries – such proposals are submitted to the respective funding agencies of each country. We can address specific country collaborations offline on a case-by-case basis. Please contact the program officer involved. No funds from NSF can be allocated to international participants.

Slide 30: Questions?

The moderator will now guide you through the Q&A session.