



## Request For Proposal: Open Web of Things An Internet of Things Research and Open Innovation Expedition

### Technical Leads:

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### Introduction

Google is soliciting proposals for pioneering research related to the Internet of Things. This is a cross-disciplinary expedition intended to address the complex challenges and opportunities before us as we explore the next generation of systems, services and Internet-connected devices. Open innovation<sup>1</sup> is a core principle of this program to make the Internet of Things a reality for everybody.

The mission of this program is to enable effective use and broad adoption of the Internet of Things by making it as easy to discover and interact with connected devices as it is to find and use information on the open web. The resulting open ecosystem should facilitate usability, ensure privacy and security, and above all guarantee interoperability.

People no longer need to sit at a desk to get the benefits of networked technology. However, the experiences we build across the Internet of Things can do more than allow for usage throughout the day and out in the world, they can assume it. They can do more than work nicely with the existing technology in our lives, they can work seamlessly across all of it. As we remove abstract barriers, such as what functionality resides on what device, our users should be able to focus more on what they're doing and less on how to start doing it.

To be great, these experiences should do for the user what was not previously possible with

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<sup>1</sup> Chesbrough (2003) [Open innovation: The new imperative for creating and profiting from technology, 2003](#); [Democratizing innovation, E Von Hippel - 2005](#); Spohrer et al (2008) [Service Science: Reframing Progress with Universities](#)

existing technology. They should take seriously the impact of computing in someone's everyday life especially in areas of security, privacy, and trust. Ultimately, they should delight the user with reliable and simple solutions to their needs, while never taking precedence over their life.

Towards these goals, Google is planning to set up a research and open innovation expedition to explore the foundational elements necessary to enable easy development of smart and secure Internet of Things applications and services. We envision research at the intersection of disciplines including (but not limited to):

- Human-Computer Interaction (HCI)
- Privacy & Security
- Systems & Protocols

A variety of Google experts and product groups will play a role in this expedition, either by contributing expertise, or providing related technology. Google researchers and experts involved in this program include, but are not limited to the following business platforms: Android, Chrome, Cloud Platform, and Internet connected home products like Nest.

### Expedition Lead Grant & Individual Project Grants

For this research expedition we are inviting two types of one year seed research proposals meant to bootstrap a cross-disciplinary research and open innovation effort:

#### Expedition Lead Grant

We strongly believe in a comprehensive approach that dovetails (1) user interface and application development, with the goal of making the Internet of Things easy to use; (2) privacy and security, focusing on identity management and safety, and (3) systems and protocols research, to support the intended user experiences and interoperability. Importantly, we are open to new and unorthodox solutions in all three of these areas, for example, novel interactions, usable security models, and new approaches for open standards and evolution of protocols, *e.g.*, DLNA, Zeroconf, SDN, Thread, and HTTP.

Researchers interested in the Expedition Lead Grant should build a team of PIs and put forward a proposal outlining a draft research roadmap both for their team(s), as well as how they propose to integrate related research that is implemented outside their labs (*e.g.*, Individual Project Grants, below).

The one year Expedition Lead Grant ranging from USD \$500,000 - \$800,000 is meant both for program management as well as funding mostly graduate level research (PhD./post doc). We encourage applications from PIs who are willing to dedicate a substantial portion of their research time to this expedition. For the graduate students funded through the program we assume a significant portion of their time will be dedicated to this research.

### Individual Project Grants

Building on the scope of the Expedition Lead Grants described above, we also are soliciting one-time awards ranging from US \$50,000 to \$150,000 in the following areas (1) user interface and application development, (2) privacy & security, and (3) systems & protocols research. Particular attention will be given to proposals that demonstrate innovative solutions that support user centric work practices around the Internet of Things.

### Overall Mission of the Research & Open Innovation Expedition

Enable effective use and spur broad adoption of the Internet of Things by making it as easy to discover and interact with connected devices, as it is to find and use information on the open web. The resulting open ecosystem should facilitate experimentation with applications and user experience, ensure privacy and security, develop systems and protocols that guarantee interoperability.

### Guiding Principles

- Innovation driven by users and developers, without permission, and in open markets
- Effective governance institutions and practices
- Acceptance and adoption of technology
- Reuse of existing infrastructure (incl. legacy devices, downward compatibility)

Additionally, this program will help Google learn what we can offer to help lower the barrier of entry to users/developers. For example: storage space for signals/data, computational resources, “black boxes”/open source tools that implement commonly needed functionality such as voice recognition or gesture recognition.

### Mission and Research Interests for User Experience & Applications

Research and develop the building blocks for an Internet of Things development framework and HCI techniques. Key components are a common user interface paradigm, libraries and services, enabling easy-to-use applications that can fully utilize the Internet of Things.

### Research Interests

We envision research projects to identify and answer challenging social interaction questions, including but not limited to:

- Use cases and applications: emerging needs; heterogeneity; multi-device simultaneously and sequentially; shared devices and roles
- Input and output: new sensors; optimization of existing sensors; UI techniques.
- UX: HCI for (screenless) Internet of Things devices; adaptive interfaces; managing information/thing overload (incl. spam & malware); common design patterns and interaction techniques; common interaction and object ontology; default settings; multi-device interactions

- Management: effective configuration, maintenance, reliability and replacement needs of a vast array of devices (automation)
- Ease of Use: barriers to entry; social acceptance; visualization and control of data collection and usage; machine learning of user-preferences, -patterns and -context; public devices; personalization; recommender systems; crowdsourcing acceptable practices and default settings
- Programming: end user programming; scripting; UI toolkits; automation.

### Mission and Research Interests for Systems & Protocols

Research and develop the infrastructure framework (conceptual architectures & functional protocols) for interactions among users and networked things that are reliable, resilient and energy-efficient (both in terms of spectrum and power).

#### Research Interests

We envision research projects to identify and answer challenging social interaction questions, including but not limited to:

- Reliability: consistent IPv6 addressing, even for mobile devices; verifiability of protocol- and system-level properties; predictable latency and performance with real-world consumer networks
- Resilience: discovery across multiple protocols; intermittent connectivity; transfer of ownership of devices (and their manufacturers); minimize exposure to “war-driving”
- Efficiency (Spectrum and Power): support diverse air interfaces (radios) and encourage innovation to save power and spectrum; consistent APIs across diverse approaches to naming, signaling, control, and security across interfaces
- Interoperability: Common data formats and schemas for mashing up data streams by time, location, place, etc.; supporting selective-availability of data at multiple resolutions/precision based on trust between parties. Zero-configuration discovery.
- Developer Productivity: REST-derived architectural styles for composing systems and corresponding tool support (analogous to LAMP); conventions for common APIs (on/off, delayed actions, recurring schedules)
- Middleware: data processing at intermediate stages of the network; mobile code for data reduction; specialized Big & Fast data processing in the Cloud for Internet of Things data
- Data management: edge vs. cloud; data reduction, latency and security for IoT sensors and devices, delay tolerant networking (DTN) for IoT

### Mission and Research Interests for Privacy & Security

Research, design, and develop technologies that provide authentication, integrity and reliability in Internet of Things systems. Provide users with broad controls over personal data ownership, inform users about data provenance, as well as create design tools to help users

understand the tradeoffs between sharing and not sharing personal data with services in the Internet of Things environment.

### Research Interests

We envision research projects to identify and answer challenging social interaction questions, including but not limited to:

- User Consent: redefinition of consent; methods to obtain (no checkbox, impossible to ask); interaction with invisible devices and ensembles of devices; revocation, narratives and metaphors
- Privacy Policy and Permissions Control: Policy spanning multiple heterogeneous devices (joining multiple policies, inheriting policies); level of granularity (apps, sensors, network environment, location, device ensembles, etc)
- Data Deletion: level of granularity; automatic deletion; simplification of deletion across multiple sensors and/or services; responsibility of downstream systems to respect requests to delete data or derivations
- Authentication Services: clean slate approach; safety standards; need for Internet of Things safety authorities; decentralized Internet of Things authorities; decentralized version of DAA; access permission templates in a smart home; role management (e.g. postmen, kids, parents, etc.)
- Identity Management: multiple identity management; group identities for an ensemble of devices; protocol identifiers and their interaction with user policy; etc.
- Scalability of Key Management: managing billions of certificates, device heterogeneity
- Data Access Transparency: Visibility into collection of sensor data by applications
- Private user data storage: architecture and management of private clouds; efficiency for large quantities of data
- New Security Threats: detect, prevent and counter emerging risks; interaction of private and non-private devices
- Monitoring: Sensor monitoring (e.g. appropriate sampling rates for aggregation); location inference; prevention of fingerprinting (e.g. solutions beyond MAC address rotation which may still be flawed for obfuscation); tracking policy compliance.

### Award Information - Format & Process

We are requesting proposals from university faculty members, and we would be delighted with your participation. We expect to make several awards to universities under this program, and welcome proposals that include investigators from multiple organizations where appropriate, though all PIs must be full-time faculty members at accredited universities.

Proposals will be selected based on merit of the addressed use case(s) in terms of value for the user and effectiveness of the technical, business and governance ecosystem. Chosen proposals will demonstrate ability to accomplish outlined goals within one year and will address one or more of the identified research interests. The

proposal should clearly convey that the PI has the knowledge and capability to achieve the stated research goals and while any research program will have uncertainties at the proposal stage, there is a clear roadmap addressing the key challenge areas. Depending on the proposals we receive, Google maintains discretion of the level of investment made.

You should include the following in your proposal:

- Proposal Title
- Principal Investigator (PI) full name, contact information (postal address, e-mail, phone)
- Collaborators within and outside your organization
- Research objectives and expected results
- If you have contacts in Google areas where your research may align, please include their names. Please note however that this is not necessary
- Benefit to the research community
- Budget Summary: Please briefly list only high-level line items like students, study costs, travel, etc. Google may offer help in hosting data, providing Google App Engine computational credits, or other engagement as appropriate, so please specify if you have ideas about using Google platforms
- Percentage of time planned to dedicate to this research project (both PI and individual researchers)
- University's policy regarding sharing of data, code and outcomes from the research
- Opportunities to incorporate IoT related project-based learning and experiments into your course work.

Please be concise, but clear. As guidance, we'd prefer the body of the proposal to be 3-4 pages maximum for either grant. You might refer to this [guide](#) for some specific writing advice [1]. At the end of the proposal, please attach a two-page summary CV that includes a list of 5-10 examples of past publications done by the PI and collaborators.

For both grants, these are one-time awards for one year. Awards are structured as unrestricted gifts to the universities, so we do not allow overhead or indirect costs. Where appropriate, we would appreciate if award recipients made their software, utilities, data sets, papers, or similar artifacts freely available for others to use via open source permissive license (e.g., Apache), publication, etc. Google would also appreciate attribution or acknowledgment of our gift in publications, and news about how the gift is used whenever appropriate.

In addition to funding, program participants will be invited to participate in an Open Web of Things Base Camp in the fall of 2015, bringing together the first results of the research funded as well as other research that addresses the mission and research interests above.

## Open Web of Things - RFP

To submit your proposal, please [fill out this form](#) and then email your PDF proposal to [openexpedition-awards@google.com](mailto:openexpedition-awards@google.com). The title section of your PDF proposal should include the email address of the primary PI.

All materials submitted by you in connection with your proposal must only contain public information -- please do not submit any proprietary, confidential, or non-public information. Google has no obligation to return any submitted materials.

The deadline for submissions is **January 21st, 2015**. We expect to select proposals early Spring 2015. Selected PIs will be invited to participate in a kick-off workshop at Google shortly after.

If you have a technical or scope question, please contact Roy Want ([roywant@google.com](mailto:roywant@google.com)). Please direct any questions you may have about the process for these awards to Max Senges ([maxsenges@google.com](mailto:maxsenges@google.com)).

Researchers interested in IoT areas not covered by this open call for proposals are encouraged to review [Google's Faculty Research Award program](#) and consider submitting research proposals there.