Position paper for Internet of Things (IoT) workshop, March 2011

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This paper has three parts: a general proposal for how the IoT topic is dealt with in the IETF and elsewhere; an outline of the concept of "building networks"; and a listing of specific problems within that that need attention.

IoT and networks

The topic area of Internet of Things covers a very wide range of applications, with very different goals and components, which ultimately put different needs on network technology. The background introduction to the event notes that "There will be a lot of variation …" in key attributes. It is useful to consider what services are needed by most or all devices that participate in some form of the IoT so that they can be enabled in standards. A second approach should also be taken: identifying a number of discrete applications and considering what is required for each of them, and then considering what common elements some or all of these may have. These two approaches are complementary, not in conflict.

The concern here is that the great range of IoT makes it difficult to have conclusive discussions as people will bring varied assumptions about what devices are in question to each issue. Also, while many IoT devices will have constraints, as the initial discussion notes, the nature of the constraint will vary among device types.

The premise here is that having sub-topics of IoT will help organize and streamline the discussions in Prague and beyond, and so make the effort more efficient and productive. We should expect people to frequently make general statements about what is required for IoT development when they have their specific application area in mind. Being able to qualify these statements can help facilitate communication. We also need to keep an open mind about what network services can be made universal across most or all sub-topics, and which are better kept as application-specific.

We will benefit by having a finite number of named and reasonably well-defined sub-topics to aid our discussions. I have not tried to catalogue the possible major topic areas under IoT, but clearly they include sensor networks, industrial networks, body networks, and as below, building networks.

Building networks

Building networks is a proposed name for the connectivity among devices in buildings that use energy (lighting, heating, appliances, electronics, etc.), those that strongly influence it (windows, doors, etc.), and human beings. Building networks differ from some (not all) other IoT sub-topics in the core role that people play in interacting with the network, and needing to be represented in it. A building network will not be separate from the IT networks we have today, but will be more an expansion of today's networks.

Research problems

Highly functional building networks that we would like to have in 5, 10, or 20 years rely on solving a number of problems. What organization(s) should do this, and what role the IETF plays in each is not addressed here. These problems are not in any particular order.

Location

Devices in a building need to be able to discover where they are physically in the room they are in, and how that room relates to others surrounding it. Devices can be physically close but on opposite sides of a solid wall. Some walls are opaque to light, but not sound. Discovering location in some automated way(s) is challenging. Location can be specified unambiguously at the cost of great complexity, but we need to have way(s) of doing so that are as simple as feasible. Many objects move.

People and devices travel from country to country, so that the solutions to all these problems need to be universal globally.

Identity

Devices in a building need to expose their identity to others in a way that is useful to others, both in generic terms ("I am a light source" or "I am a computer display") to the specific ("I am the second floor refrigerator" or "I am the main lobby door"). A categorization of relevant objects needs to be created similar to what we have for animal and plant species.

Authority

Devices will begin by controlling their own destiny, but will need to cede authority to others in some contexts and circumstances. Ensuring that this occurs when it should — and does not occur when it should not — is a challenge.

People

Humans need to be considered as nodes on the network, with a data representation that devices can acquire and use. This may be anonymous in some circumstances, or with people's identities manifest in the network in others.

Privacy

Building networks need to be able to serve the needs of their occupants, without requiring that they also be inherently spies on them at the same time (since for the most part, the same data are involved).

Security

Needless to say, this will be a critical and difficult part of building networks.

Preferences

Devices need to operate taking into account the preferences of people occupying the spaces they are in, or who manage or control those spaces. Representation of preferences, and dealing with conflicting preferences, are research challenges.

Prices

An obvious benefit of networking energy-using devices is to enable them to automatically respond to dynamic conditions in the supply system, best represented through price (a current price and price forecast as for 24 hours ahead). This may actually be one of the easier challenges to deal with, but should be implemented at an early stage.

Network architecture

Building networks should use standard IP protocols (those existing and presently in development in the IETF). On top of that, is a collection of application layer protocols, data models, representations of the real world, standard device behaviors, and such, that

together enable building networks to operate at all, and in the way we want them to. This is a structure built on top of the IP base that needs to be well-organized and described. Describing this is not only important for those who will design and use its components, but also to be able to describe it to the wider public. Perhaps much more than with the current Internet (largely limited to the information world), this architecture will affect people in their ordinary life in both commercial and non-commercial contexts. Paradigms, metaphors, and terms used for this need to be very carefully chosen. In many cases we will take existing concepts (e.g. a "room") and bring it into the digital domain. In other cases, we will create new concepts (e.g. background preferences).

User interfaces

Much of the network technology will inevitably appear in user interfaces, much as the email address scheme of our current network does. Doing this in a way which best matches the needs, desires, and capabilities of diverse users is difficult, but doable.

Anomalous conditions

Equipment fails and emergencies happen. People may interact most intensively with devices (at least for their network aspect) when something goes wrong. After all, when it works, the operation is most successful if it recedes into the background. Thus, careful design needs to go into these situations, as much or more than into normal operation. Indeed, for a device to know when something is wrong is a challenge itself.

This list is not complete, but should cover the significant majority of research needs for developing robust and highly functional building networks. Many of these will also be necessary and useful for other sub-topics of the IoT. Not all need to be solved immediately, but some are likely necessary for a minimal first version of building networks.

Some of these topics the IETF may choose to take on itself, in whole or in part. For some others, the IETF can provide good guidance and insight to whatever organizations do.