Simple Scaling for RFID-based Pervasive Computing Systems

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Background

Josh and David have both worked on RFID-based pervasive computing systems for the past several years. Josh has developed a programmable passive RFID tag called the WISP with a variety of sensors that is capable of harvesting power from and communicating with commercial RFID readers. David has developed a programmable (SDR-based) RFID reader and used it and the WISP to build and measure RFID-based network systems. The target for this work is pervasive computing systems, in which sensing and computation is embedded in everyday objects via smart RFID tags. A few examples of application scenarios that have been prototyped with the WISP include: activity detection from object motion traces for eldercare to help elders live in their homes for longer; robot systems that use RFID to learn about the environment; and gesture recognition from accelerometer data to turn everyday objects into HCI interfaces. Josh and David also have a general exposure to the field of pervasive computing through their work at Intel Labs Seattle, an exploratory research lab that is focused on exploring computing systems that are woven into the fabric of everyday life. They have published work, for instance, in venues such as Ubicomp, Pervasive, and CHI.

Vision

To date, the pervasive computing systems that we have built using the WISP are at small scale, typically demonstration environments. We are presently trying to scale up these systems to the building level using the RFID ecosystem at the University of Washington (in which an entire building is outfitted with RFID readers). This involves several challenges, such as allowing multiple pervasive computing applications to co-exist in the same RFID environment, scaling the ability to communicate identifiers and sensor data with RFID to the entire building, and searching for individual tags over the spatial extent of the building. As the size of our systems increases further, the centralized design we presently operate will become difficult to scale. Thus we appreciate the motivating issues for the workshop.

The approach we are taking might best be described as "simple scaling". Our vision is to flip the traditional RFID system of a controlling reader and many subordinate tags on its head and transform it to a more traditional Internet architecture. In our architecture, RFID tags that are embedded in objects are in control. They decide what application program to run and what data to communicate when, including whether to reveal themselves to readers in the first place. RFID readers supply power and connectivity to the Internet rather than acting as an endpoint of communication. (Even though readers are necessarily in control at the PHY layer of

RFID since the reader provides power to the tag, it is possible to build higher networking layers, in which the tags are in control. For example, the reader could periodically poll the tags to ask "Do you want power to initiate a data transfer?") In this way a component of a pervasive computing application running on an RFID tag can communicate with other application components that are network accessible, regardless of whether they are co-located with the reader. That is, our vision entails an integration of RFID with the Internet architecture. (The general name for this topic is "Internet of Things". However, most visions in this area do not identify the issue of reader versus tag control that we believe is central to scaling.) It is likely that RFID readers would offer other services too, such as storage for "delay tolerant networking" exchanges between pervasive computing components operating in the same physical location at the same or different times.

"Evidence"

Our approach is simple and tantamount to decentralizing while avoiding known, complex scaling problems – we believe it is valuable for advancing pervasive computing systems precisely because it solves only the minimal set of problems that must be tackled to scale RFID-based pervasive computing systems. That is, it can allow the community to quickly experiment and gain experience at scale with at least some kinds of pervasive computing systems. Our optimism surrounding "simple scaling" is founded on the success of the Internet. By flipping control from RFID readers to tags, we cast tags in the role of endpoints or Internet hosts, and readers in the role of routers. The closest analogy is perhaps with an RFID reader as a WiFi access point (AP) that is providing connectivity as a service. This allows a very large number of laptops to be used outside of their home service areas with little effort. Given this approach, we can leverage the large body of work on topics like routing to allow applications running on tags to communicate with applications elsewhere on the Internet, all without centralized components of any form. Like the Internet architecture, this architecture would allow innovative applications to be developed and easily support multiple applications in the same space. We hypothesize that this approach would substantially reduce the cost of deploying complex applications, particularly ones that require communication across RFID reader networks that are not managed by the same entity. There are other concerns that may interfere with scaling that we have not yet examined deeply, such as security. However, we believe that simple scaling is worth exploration and could provide a quick route to experimental pervasive computing systems at scale.