Using CCN for Discovery of Missing Physical Items

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1. INTRODUCTION

As the number of connected devices to the Internet scales up, as the amount of traffic generated by these devices explodes, it is necessary to reconsider the underlying protocols which will support the Internet of Things. As many devices in the IoT may be sensors or devices which need to provide some information but would not require complex network configuration, Information Centric Networks [1–4] and CCN/NDN [5, 6] in particular, has been suggested as a potential candidate for the IoT (we just use CCN below, and in our implementation, but NDN could apply as well).

CCN offers interest-data semantics which have history in sensor networks and Directed diffusion [7] in particular. CCN issues an interest packet, which carries the name of the desired information; this packet is routed to the proper place where to find/collect/gather the information called in the name; once the information which matches the name is found, it is packaged into a data object which is returned to the original requester. In order to trace back the route of the information to the requester, the interest packet leaves a state at the router, as an entry in a Pending Interest Table (PIT), which points to the interface which received the interest, and therefore where to send back the data. This state is kept for a time-out value, which can be specified by the interest/sender and be refreshed periodically. In other words, CCN enables to place semi-persistent state in the network waiting to be fulfilled by some data.

In this demo, we propose a cyber-physical application of the abstractions natively offered by CCN to emulate an existing function called Tile [8]. Tile is a bluetooth tag combined with a cell phone application; the tag is attached to a valuable object. If the object is misplaced or stolen, a central server is contacted, which pushes the tag ID onto all the nearby devices running the application. The devices then probe for the Bluetooth signal of the tag. If they encounter the tag, they send a response to the server with the tag's position and time.

For such system to be worthwhile, it requires widespread adoption. Indeed, the distributed scanning ability required to retrieve the tag, and therefore the value of the system, hinges on the number of devices carrying out the scanning. Such a service is not valuable until it has many users to detect tags. However, since early adopters would only see little value until that critical mass is reached, they would be less likely to encourage others to adopt.

ICN'15, Sept.30–Oct. 2, 2015, San Francisco, CA, USA.
ACM 978-1-4503-3855-4/15/09.
DOI: http://dx.doi.org/10.1145/2810156.2812613.

2. DEMO DESCRIPTION

We contend that having the operator provide the tag location service would break this vicious cycle; the operator would lay out a one-time deployment cost to associate the service with its infrastructure, but would then achieve coverage and be able to deliver value to the users. The operator can for instance associate the scanning with low power WiFi on top of a set of hot spots, or add a Bluetooth scanning capability to set-top boxes such as Orange's Livebox home gateway. A network operator can also ask its phone manufacturing partners to include the scanning functionality as a low-power background function on locked devices.

The point of the demo is to implement this function on top of CCN. It is of course possible to implement it over IP, but we wish to demonstrate the ease with which CCN enables us to deploy this function. Basically, CCN enables to send an interest with the tag ID that we are trying to locate, have this interest be distributed throughout the network, and to have a response to the interest (namely, a sighting of the target tag) be delivered back to the origin server. These are native semantics of CCN, and therefore come at no cost for the tag location application developer.

We have deployed such a system in an actual testbed. The testbed is described in Figure 1. For the demo, we use a Dell latitude laptop for the gateway, and some Raspberry Pi nodes running PARC's CCN code for Raspberry Pi with a CSR USB dongle attached. A script scans for bluetooth IDs at regular interval, and keeps a log of the encountered IDs at the Raspberry Pis. For the tag, we use the bluetooth interface of a cell phone, which is easy to turn on or off. On the gateway, a user interface allows to specify which tag ID to try to locate. Once a tag ID is entered on the UI of the server, it is propagated to the Pi boxes. The Pi boxes scan for bluetooth devices and keep track of the devices that they see. If they see the desired tag ID, a response to the interest is generated and propagated back to the server.

We have implemented a GUI which resides on a web server, and a gateway that translates the requests coming from the current Internet into the CCN domain.

The demo will show how to locate the tag ID of the cell phone of the demo participants (or of the demo host). When

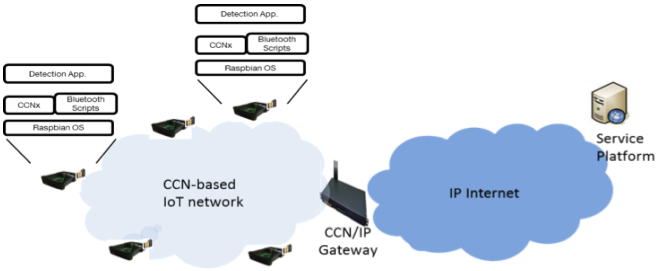

Figure 1: Testbed for tag location function.

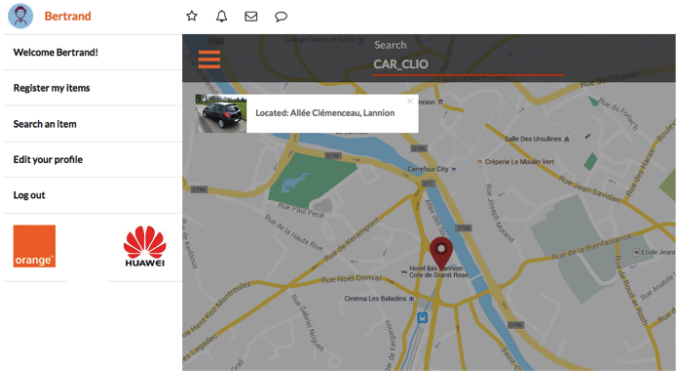

Figure 2: The user inputs the information and views the tag's location on a specific GUI

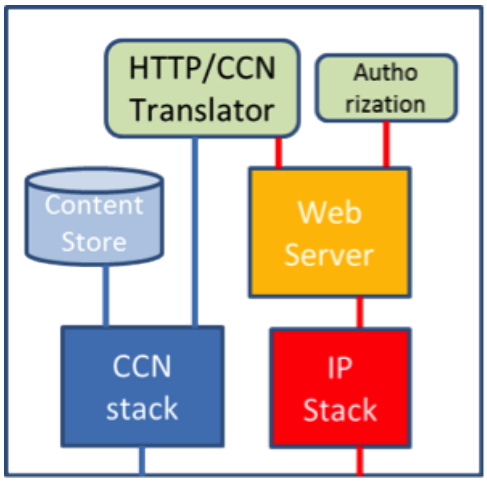

Figure 3: Gateway function to interconnect the current Internet with the CCN domain

the cell phone will be in contact with a Raspberry Pi, an alert will be send back and displayed on the screen of the gateway.

3. DISCUSSION & FUTURE WORK

The multicast features of CCN allows to forward an alert to multiple end points: the gateway of the function, but also the tag's user or the local authority to retrieve the missing tagged item. The demo uses a single interest per requested ID; therefore it would not scale to a large number of items nor to a large area to cover. Future work includes considering the scalability issues of such a set up. In particular, aggregation of the tag IDs through a Bloom Filter would allow the server to issue interest for multiple tags at the same time. Similarly, scoping the interests of specific tags to specific locations (and expanding the search radius as time goes on) would reduce the burden on the system. Building a hierarchy of servers would allow to filter out false positives of the Bloom filter without getting all the way to the

Another generalization of the demo is in the direction of logistics: can the network keep track not only of a subset of desired IDs, but of all IDs which belong to a system (say, inventory of a company on a corporate campus) and assist in the logistics. One could for instance imagine a library where miss-shelved books could be retrieved. The basic function of generating an inventory would become a function that is easily supported by the network infrastructure.

We believe that CCN easily, cleanly and natively support some cyber-physical features to locate items in the physical world and that it is a significant advantage over using IP networks in such a system. We note that such a system could be implemented over IP as well, but would require much more work, in particular to configure a new node into the system.

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