ENUM based Service Discovery Architecture for 6LoWPWN

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Outline

- Service Discovery (SD)
- Ubiquitous Sensor Network (USN)
- Wireless Sensor Networks (WSNs)
- Electronic Number Mapping (ENUM) protocol
- IPv6 enabled Low power Personal Area Networks (6LoWPANs)
- Naming Authority Pointer Records (NAPTR)
Question

- Wireless Sensor Networks (WSNs)
  - The nascent “IPv6 over Low power Personal Area Networks” standardized as 6LoWPAN by the IETF, transmits IPv6 packets over LoWPAN.
ENUM

- Provides Naming Authority Pointer (NAPTR) records for finding out the path to the requested service.
- E.164 numbers
  - These numbers provide numbering scheme for services in the ENUM protocol.
## DNS

<table>
<thead>
<tr>
<th>E164 number</th>
<th>E164 number converted to domain name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Country Code (ac)</strong></td>
<td><strong>Subscriber Number</strong></td>
</tr>
<tr>
<td>cc = 3 digits</td>
<td>Maximum = (15–cc) digits</td>
</tr>
<tr>
<td>+82</td>
<td>31219001</td>
</tr>
</tbody>
</table>
Advantages of ENUM

- ENUM as a service discovery protocol in 6LoWPAN offers many advantages. Some of the advantages are listed below:
  - E.164 numbers
  - ENUM to URI (E2U)
  - DNS infrastructure
Method

- **Sensor nodes**
  - initiate queries based on attribute-value (av) pairs
    - [Country = Korea [city = Suwon [building = Sanhak Won - Ajou University]]]

- **Master node**
  - forward this query to the gateway
Three Types of Architecture Based SD Approaches

- Centralized directory based
  - Is used where a dedicated server is maintained
    - DNS-based Service Discovery (DNS-SD)
- Hierarchal architecture based
  - Proxy-Enabled Service Discovery Architecture
- Fully distributed architecture based
### E.164 number convers to a domain name

<table>
<thead>
<tr>
<th>E164 number</th>
<th>E164 number converted to domain name</th>
</tr>
</thead>
</table>
| **Country Code (ac)** | **Subscriber Number** | **1. Reverse the number**  
| **cc = 3 digits** | **Maximum = (15–cc) digits** | **2. Separate them with dots**  
| +82 | 31219001 | **3. Add the e164.arpa suffix**  
| | | **1.0.0.9.1.2.1.3.8.2.e164.arpa** |
Architecture

Incorporates ENUM as a SD protocol in WSNs.

A. Service Discovery using ENUM

B. Service Query – (Attribute-Value pair (AV-pair) to E.164 Mapping)

C. Inter LoWPAN Service Discovery

D. Basic Assumptions

E. Service Look up Latency

F. Traffic Overhead
Figure 1. General framework
Figure 2. ENUM based service discovery model
AV-Pair to Integer (E.164 number) Mapping

<table>
<thead>
<tr>
<th>Human readable Service String</th>
<th>Attribute</th>
<th>Country</th>
<th>City</th>
<th>Building</th>
<th>Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>Korea</td>
<td>Suwon</td>
<td>Sanhak Won - Ajou University</td>
<td>temperature</td>
<td></td>
</tr>
<tr>
<td>Integers based Service String</td>
<td>E.164 number</td>
<td>+82</td>
<td>31</td>
<td>219</td>
<td>001</td>
</tr>
</tbody>
</table>

**TABLE II** AV-PAIR TO INTEGER (E.164 NUMBER) MAPPING
Inter LoWPAN Service Discovery

- SR -> Service Request
- R-URIs -> Reply with URIs of Service Provider
Performance Evaluation

- PcacheHit : master node cache hit
- Packets generated : (Ocache + Osd)
  - Ocache : packets are sent in the cache hit case
  - Osd : the number of packets generated for the SD purpose
- Total time : (Tcache + Tsd)
  - Tcache : round trip time required
  - Tsd : total time taken for cache miss SD
# Variables

## TABLE III

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>Total number of nodes</td>
</tr>
<tr>
<td>$R_{req}$</td>
<td>Service Request rate i.e. number of queries per client node</td>
</tr>
<tr>
<td>L</td>
<td>Average number of hops from client node towards master node</td>
</tr>
<tr>
<td>$P_{cacheHit}$</td>
<td>Probability of Cache hit for the queried service</td>
</tr>
<tr>
<td>$D_h$</td>
<td>One hop delay</td>
</tr>
<tr>
<td>$D_t$</td>
<td>Transmission delay in the Internet</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>Data rate (queries per second)</td>
</tr>
</tbody>
</table>
E. Service Look up Latency

\[ T_{xp} = 2 \left( D_h \times R_{req} / \lambda \times L \times N \right) + \\
(1 - P_{cacheHit}) \times (N \times D_t \times R_{req} / \lambda) \]
F. Traffic Overhead

\[ O_{\text{exp}} = (2 - P_{\text{cacheHit}}) \times (2 \times N \times R_{\text{req}}) \]
Comparison

- Proxy based hierarchal infrastructure service discovery
- Portal based service discovery
Figure 4. End to end latency versus service request generation rate
Figure 5.
End to end delay versus path length
Figure. 6 **Bandwidth utilization versus service request generation rate per client**
Conclusions

• ENUM protocol offers simple mechanism to perform SD on global scale and results in lower service access network delay and lower bandwidth utilization.

• It is also observed that there is a significant improvement in results over previous work while accessing the services which are not within the proximity of the client.
Thanks for your Attention.

Q & A
6LoWPAN

- 6LoWPAN is an acronym of *IPv6 over Low power Wireless Personal Area Networks*. 6lowpan is the name of a working group in the internet area of the IETF.
- The 6LoWPAN concept originated from the idea that "the Internet Protocol could and should be applied even to the smallest devices," and that low-power devices with limited processing capabilities should be able to participate in the Internet of Things.
- The 6lowpan group has defined encapsulation and header compression mechanisms that allow IPv6 packets to be sent to and received from over IEEE 802.15.4 based networks. IPv4 and IPv6 are the work horses for data delivery for local-area networks, metropolitan area networks, and wide-area networks such as the Internet. Likewise, IEEE 802.15.4 devices provide sensing communication-ability in the wireless domain. The inherent natures of the two networks though, is different.
- The base specification developed by the 6lowpan IETF group is RFC 4944. The problem statement document is RFC 4924.

http://en.wikipedia.org/wiki/6LoWPAN

ENUM based Service Discovery Architecture for 6LoWPAN
Service Discovery (SD)

- Service discovery protocols are network protocols which allow automatic detection of devices and services offered by these devices on a computer network.
- Service discovery is an essential ingredient of the Semantic Web, since the future Web must allow software agents to make use of one another's services without the need for continuous user intervention.


ENUM based Service Discovery Architecture for 6LoWPAN
The **Simple Service Discovery Protocol (SSDP)** is a network protocol based on the Internet Protocol Suite for advertisement and discovery of network services and presence information. It accomplishes this without assistance of server-based configuration mechanisms, such as the Dynamic Host Configuration Protocol (DHCP) or the Domain Name System (DNS), and without special static configuration of a network host. SSDP is the basis of the discovery protocol of **Universal Plug and Play** and is intended for use in residential or small office environments. It was formally described in an IETF Internet draft by Microsoft and Hewlett-Packard in 2499. Although the IETF proposal has since expired, SSDP was incorporated into the UPNP protocol stack, and a description of the final implementation is included in UPnP standards documents.

Cache

- When the cache client (a CPU, web browser, operating system) needs to access a datum presumed to exist in the backing store, it first checks the cache. If an entry can be found with a tag matching that of the desired datum, the datum in the entry is used instead. This situation is known as a *cache hit*. So, for example, a web browser program might check its local cache on disk to see if it has a local copy of the contents of a web page at a particular URL. In this example, the URL is the tag, and the contents of the web page is the datum. The percentage of accesses that result in cache hits is known as the *hit rate* or *hit ratio* of the cache.

- The alternative situation, when the cache is consulted and found not to contain a datum with the desired tag, has become known as *cache miss*. The previously uncached datum fetched from the backing store during miss handling is usually copied into the cache, ready for the next access.

http://en.wikipedia.org/wiki/Cache#Web_cache
Naming Authority Pointer Records (NAPTR)

- Uniform Resource Names (URNs) are a subset of Uniform Resource Identifiers (URIs) used for abstract identifiers, such as a person's name or their telephone number. For URNs to be meaningful, they must be mapped to a concrete resource of some sort. Uniform Resource Locators (URLs) are often used to describe such resources, such as a computer hostname, or a local file.

- As part of the standardization of URNs, NAPTR records were introduced to do just this. NAPTR records map between sets of URNs, URLs and plain domain names and suggest to clients what protocol should be used to talk to the mapped resource. Each NAPTR record contains a service name, a set of flags, a regexp rule, an order value, a preference and a replacement. Multiple records can be chained together in a cascade to rewrite URIs in fairly sophisticated, but deterministic ways. These cascading rules have been standardized in RFC2915 and RFC3403.

http://en.wikipedia.org/wiki/NAPTR_record