Performance of Host Identity Protocol on Nokia Internet Tablet

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Outline

- Nokia 770 specifications
- Porting items
- Test environment
- Basic HIP properties and non-HIP characteristics measured
- Measurement results & Analysis
- Conclusions
Why Nokia 770?

- PDA with very limited resources
- Mobile client (HIP supports mobility)
- Great amount of applications that might utilize the benefits of HIP (i.e. *Internet Telephony*, *Web*, *Media* etc.)
- Linux-based (open source platform, easy porting)
Technical specifications

● **Processor**
  - a 220-MHz, ARM9-based Texas Instruments (TI) OMAP 1710

● **Memory**
  - 64 MB DDR RAM
  - user-available 64 MB of internal Flash
  - RS-MMC (Reduced Size – MultiMediaCard) slot up to 2 GB currently

● **Connectivity**
  - WLAN – IEEE 802.11b/g
  - Bluetooth 1.2

● **Power**
  - a 1500-mAh BP-5L Li-Polymer battery

● **Operating System**
  - Internet Tablet OS 2006 edition (embedded Debian)
    - GNOME-based graphical user interface
    - Linux 2.6.16 kernel
Porting HIPL to Tablet

• Customizing Tablet's kernel to support HIP
  - patching, configuring

• *Scratchbox* cross-compilation toolkit
  - cross-compiling the kernel and HIPL userspace code

• Packaging software to be deployed on the device

• Flashing kernel image, installing packages
Network Setup

Ubuntu 6.06 Dapper Drake
Linux Kernel 2.6.15.7

Intel Pentium 4 CPU 3.00 GHz
1 GB RAM

IEEE 802.11g

Switch

Nokia Tablet
Embedded Debian
Linux Kernel 2.6.16

Tablet-to-PC
Tablet-to-Tablet
Laptop-to-PC

Intel Pentium 1.6 GHz
IBM R51 laptop
1 GB RAM

Laptop-to-PC
Basic Characteristics

- Duration of HIP Base Exchange
- Round Trip Time
- TCP Throughput
- Duration of Mobility Update
- Power consumption
Times Measured

Initiator (Tablet, Laptop)

I1

R1

T1
(selects pre-created R1, adds puzzle)

T2
(verifies signature, solves puzzle, creates DH, signs packet)

I2

T3
(verbatim signatures, checks solution, calculates DH, signs packet)

R2

T4
(verbatim signatures)

Responder (PC)

Mobile terminal

Server
Duration of HIP handshake stages

<table>
<thead>
<tr>
<th>BE stages and total time</th>
<th>Tablet</th>
<th>Laptop</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 (PC)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T2 (Tablet/Laptop)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T3 (PC)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T6 (Tablet/Laptop)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(1024-bit keys, puzzle difficulty of ten)
Duration of HIP handshake stages (2)

Results obtained from Tablet-to-Tablet and PC-to-PC scenarios
Puzzle Difficulty Impact

R1 processing time dependence on the puzzle difficulty
Duration of Mobility Update

Average time: Tablet – 287 ms; Laptop – 100 ms
**Round Trip Time**

<table>
<thead>
<tr>
<th>RTT</th>
<th>Mean, ms</th>
<th>Standard deviation, ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC -&gt; Tablet</td>
<td>2.223</td>
<td>2.936</td>
</tr>
<tr>
<td>Tablet -&gt; PC</td>
<td>1.900</td>
<td>2.748</td>
</tr>
<tr>
<td>PC -&gt; Laptop</td>
<td>1.026</td>
<td>1.177</td>
</tr>
<tr>
<td>Laptop -&gt; PC</td>
<td>1.065</td>
<td>1.207</td>
</tr>
</tbody>
</table>

*Average Round Trip Time with various size packet*
Round Trip Time (cont'd)

PC as the initiator of the HIP BE
## TCP Throughput

<table>
<thead>
<tr>
<th>Throughput</th>
<th>Mean (Mbit/s)</th>
<th>Standard deviation (Mbit/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TCP</td>
<td>TCP/ HIP</td>
</tr>
<tr>
<td>Tablet -&gt; PC</td>
<td>4.86</td>
<td>3.27</td>
</tr>
<tr>
<td>Laptop -&gt; PC</td>
<td>21.77</td>
<td>21.16</td>
</tr>
</tbody>
</table>

*Average TCP throughput in different scenarios*
TCP Throughput (cont'd)

![Graph showing TCP Throughput](image)

- **Throughput (Mbit/s)**: The vertical axis represents the throughput in Mbit/s, ranging from 0 to 25.
- **Number of measurements**: The horizontal axis indicates the number of measurements taken, ranging from 1 to 15.

Legend:
- Tablet (plain TCP)
- Tablet (TCP/HIP)
- Laptop (plain TCP)
- Laptop (TCP/HIP)
# Power consumption

Current consumption by applications

<table>
<thead>
<tr>
<th>Applications/Mode</th>
<th>Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIP Base Exchange</td>
<td>360</td>
</tr>
<tr>
<td>ESP traffic (<em>iperf</em> with HIP)</td>
<td>380</td>
</tr>
<tr>
<td>Plain TCP (<em>iperf</em> without HIP)</td>
<td>380</td>
</tr>
<tr>
<td>Video stream from a server</td>
<td>&gt; 500</td>
</tr>
<tr>
<td>Local video</td>
<td>270</td>
</tr>
<tr>
<td>Audio stream from a server</td>
<td>400 - 500</td>
</tr>
<tr>
<td>Local audio</td>
<td>200</td>
</tr>
<tr>
<td>Browsing (active WLAN)</td>
<td>350 - 500</td>
</tr>
<tr>
<td>Passive WLAN</td>
<td>120</td>
</tr>
<tr>
<td>Activating screen</td>
<td>120 - 140</td>
</tr>
<tr>
<td>Sleeping mode</td>
<td>&lt; 10</td>
</tr>
</tbody>
</table>
Power consumption (cont'd)

- Constant data transmitting over WLAN utilizes Tablet's CPU fully
  - in this case battery lifetime does not differ much for HIP and non-HIP applications (3.5 – 4 hours)
  - both control messages and data plane consume similar amount of power at a moment
- If compared to data throughput HIP does consume more energy than plain TCP/IP
  - ESP data encapsulation requires a notably longer CPU utilization to perform a task (send a certain amount of data)
  - The more time is needed the more energy will be consumed in total for an operation by the Nokia Tablet
Conclusions

- Crypto operations cost much
  - Tablet-to-PC handshake consumes 1.4 sec
  - Two tablets need nearly two times more (2.6 sec)
  - Duration of mobility update 287 ms

- Results indicate the time for a single HIP association
  - in reality, there might be several associations at the same time

- Throughput and latency are seriously affected on the Tablet by ESP encryption involved with HIP
  - Tablet CPU constraints the accessible throughput over 802.11g WLAN to 5 Mbit/s (in contrast, 1.6-GHz laptop reaches 20 Mbit/s)
  - HIP reduces this value by 35 % for Tablet and by 3% for Laptop
  - The RTT is increased by HIP by 35-45%
Conclusions (2)

- What do results particularly mean for the end users?
  - How big delays will be in real life scenarios with different applications?
  - HIP influence on particular applications? (i.e. impact on QoS for VoIP, IP-TV etc.)
  - Benefits vs. overhead

- ...
Thank You! Questions?

- Packages and documentation available at http://www.infrahip.net/MERCoNe
HIP Mobility Update

Old IP

Nokia 770 Mobile Node
HIP Initiator

HITP Base Exchange

audio stream over HIP

New IP

Audio Streaming Server
HIP Responder

HIP Update