Ubiquitous Requirements for Internet-of-Things
- Case Study for Ubiquitous Home Gateway

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IOT for Home – Need for Home Gateway

Two Major Functionalities -
• Facilitate Home Devices to access Internet
• Access to Home Devices from Internet
### Home Infotainment Platform (HIP) - a Low-cost Internet Access Device on TV

#### Demand for a converged Low cost computing platform

<table>
<thead>
<tr>
<th>World Regions</th>
<th>Population</th>
<th>TV Households</th>
<th>Internet Users</th>
<th>Internet Connections</th>
<th>Potential Market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia</td>
<td>3,776,181,949</td>
<td>700,000,000</td>
<td>578,538,257</td>
<td>235,703,000</td>
<td>464,297,000</td>
</tr>
<tr>
<td>Africa</td>
<td>955,206,348</td>
<td>100,000,000</td>
<td>51,065,630</td>
<td>25,075,000</td>
<td>74,925,000</td>
</tr>
<tr>
<td>Europe</td>
<td>800,401,065</td>
<td>227,000,000</td>
<td>384,633,765</td>
<td>168,387,000</td>
<td>58,613,000</td>
</tr>
<tr>
<td>North America</td>
<td>337,167,248</td>
<td>114,500,000</td>
<td>248,241,969</td>
<td>80,000,000</td>
<td>34,500,000</td>
</tr>
</tbody>
</table>

- **Personalized Chat**
- **Telemedicine**
- **Home Office**
- **Home Banking**
- **Home Surveillance**
- **Distance Education**
- **Home Energy Control**
- **Infotainment**

**Notes:**
- GISFI Standardisation Event, February 2010
Technology Requirements from IOT Perspective

- Context Awareness
- QoS and Adaptability
- Privacy and Security
- Gateway Device
Context Awareness
Context-aware TV - TV and Internet Mash-ups

Live TV program

News ticker from internet

Weather Information from Internet
Intelligent Blending – Channel Logo Based EPG Mashup

- Channel logo of the currently viewed program gets detected
- Logo gets identified and the corresponding channel EPG gets downloaded
- One can have access to detailed EPG especially in non DTH environments where EPGs are not available
- Alternatively, one can click on the logo using your TV remote and navigate to the channel website using the internet gateway for additional information

Logo identified
Select text from the EPG and information gets mashed up from the internet
EPG downloaded from the internet
Intelligent Blending - OCR Based Mashup

- Pre defined key words gets automatically identified on live TV
- Key words can be texts accompanying breaking news like “Terrorist Attack”, “Tsunami”, etc.
- One can click on the identified text using your remote
- One can access detailed information corresponding to the clicked text through the internet gateway
## Some results for Logo and OCR Detection

### Logo Detection

<table>
<thead>
<tr>
<th>Channel</th>
<th>Type of show</th>
<th>Avg Time to converge (in sec)</th>
<th>Recall</th>
<th>Precision</th>
</tr>
</thead>
<tbody>
<tr>
<td>HBO</td>
<td>Movie</td>
<td>8.3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Star Plus</td>
<td>Entertainment</td>
<td>4.8</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Star Sports</td>
<td>Sports</td>
<td>3.5</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Ten Sports</td>
<td>Sports</td>
<td>3.4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Star Gold</td>
<td>Indian Movie</td>
<td>8.26</td>
<td>1</td>
<td>.98</td>
</tr>
<tr>
<td>Nat Geo</td>
<td>Report</td>
<td>7.67</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

### OCR Detection

96.57% Accuracy

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**Standardization Need** -

- Semantic Format of the Context need to be Standardized so that it can be shared across devices
QoS and Adaptability
Bandwidth aggregation over multiple WAN Interfaces

- Simultaneous data transfer (transmit and receive) through multiple active interfaces.
- Bandwidth Aggregated Faster File transfer and receive
- Dedicated Applications for Aggregated Transfer
- Future work for Application-agnostic systems

<table>
<thead>
<tr>
<th>Download File Size</th>
<th>Interfaces used</th>
<th>Observed speed in kbps</th>
<th>Enhanced data rates in kbps with aggregation</th>
</tr>
</thead>
<tbody>
<tr>
<td>30.94 MB</td>
<td>Interface 1 &amp; 2 (Photon Plus HSIA modem)</td>
<td>Interface1 = 61.436 Interface2 = 59.9</td>
<td>Aggregated rates = 101.34 kbps 43.40 / 72.45% increased data rate (best case out of 4 attempts)</td>
</tr>
<tr>
<td>141.04 MB</td>
<td>Same as above</td>
<td>Interface1 = 57.031 Interface2 = 57.031</td>
<td>Aggregated rates = 110.43 kbps 53.40 / 93.63% increased data rate</td>
</tr>
</tbody>
</table>
Rate-Adaptive Bandwidth-Efficient Video Conferencing System

<table>
<thead>
<tr>
<th></th>
<th>Mean in kbps</th>
<th>Standard deviation in kbps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adsl-adsl</td>
<td>596.1447864</td>
<td>203.454445</td>
</tr>
<tr>
<td>Modem-modem</td>
<td>19.23255948</td>
<td>26.96014122</td>
</tr>
<tr>
<td>Modem-adsl</td>
<td>18.13249667</td>
<td>3.208220763</td>
</tr>
</tbody>
</table>

Detect Network Condition in Real-time using Probe Packets

Results show reduced Quality Deterioration due to Adaptive rate Control

Estimated Bandwidth used as input to the rate control algorithm – Rate Control done inside Video Compression

Standardization Need -

- Cross-layer Communication need to be standardized in order to do real-time adaptive control
Privacy and Security
Security for Home Gateway Box

**Vulnerability**
- Open debug Ports to gain access inside box (e.g. Telnet/ssh)
- Vulnerability in Box Provisioning and Authentication
- Vulnerability in Operator Network Lock

**Possible Remedies**
- Strong MAC and User Management Policy for Debug Ports
- Chip Die-ID used as Unique ID for Provisioning and Authentication – only encrypted version of the same is sent over public media
- Use of HTTPS protocol for secure communication required for Provisioning, Authentication and Operator Network Lock
- Contemplating use of Security-hardened OS

**Standardization Need** -
- Security needs to be standardized for Gateway boxes – both from Protocol and Access-inside-box point of View
References

1. Arpan Pal, “Next Generation Internet on TV - Intelligent Mash-ups between TV Content and Internet”, *First WWW 2011 Warm-up Workshop, January*, 2010, Kolkata, India

2. Tanushyam Chattopadhyay, Ayan Chaki, Dhiman Chattopadhyay, Nandini Chatterjee and Arpan Pal, “A Novel Value Added Interactive Services for Active Pages of DTH Set Top Boxes” in *PREMI Experience Workshop 2009*
