IBBT Tr@ins project
TRAIN IP Network Services

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UGent – IBCN

05/11/2008
Railway Interiors Expo, Amsterdam RAI
IBBT: Demand driven ICT research

- eHealth
- new media
- enabling technologies
- eGovernment
- mobility

Companies
Government
Non-profit
Tr@ins project

- Apr 2006 – Mar 2008
- Tr@ins = TRAin IP Network Services
- Focus on
  - Technical
    - Broadband Internet
    - Onboard mobility support
    - Uninterrupted Internet
    - Quality of Service
  - Economical
    - User studies
    - Business model

Research groups

Industrial partners
IBBT Tr@ins project

Technical

Business model

Conclusions
Onboard network

- Horizontal handover
  - From Access Point to Access Point
  - Switch in < 50 ms for VoIP
Trackside network: WLAN Fast Handover

Fast Roaming WLAN Switch for Rail Systems

Roaming time
Average 5.64 ms
Std. dev. 0.05 ms
5 QoS-classes:

- Background: FTP
- Best effort: Surfing, Email
- Streaming: Video stream
- Interactive: VoIP call
- Priority: Crew Comm.

QoS classes are mapped on outgoing links

(Load balancing)
- Decides on interfaces to be used
- Decision based on:
  - SNR, packet loss, traffic measurements
  - GPS, speed & management info
  - IEEE 802.21 MIH events and triggers
  - Load balancing, cost
• Two alternatives
  • Mobile IP (MIP)
  • Mobile SCTP (mSCTP)
    • Multihoming
    • Reliability
    • Packet aggregation

• User devices don’t need to be mSCTP or MIP-aware
Effective L2 Throughput in a WLAN

Throughput (Mbps)

Passenger IP packet size (bytes)
Effective L2 Throughput in a WLAN

Throughput (Mbps)

- mSCTP
- MIP

Passenger IP packet size (bytes)
Flowchart business case

- Forecasting
  - Forecasting the number of train passengers
  - Determining rollout scheme
  - Calculating potential Internet on train users

- Technology assignment
  - Determining min. technology requirements
  - Computing technical scenarios

- Cost/benefit model
  - Calculating cost / benefit model

- Evaluation
  - Output business model
Forecasting

Passenger forecasting

Relation Oostende - Eupen

Adoption

Number of passengers per day

First class adoption
Second class adoption

IBBT
## Technology Assignment

### Main Scenarios

<table>
<thead>
<tr>
<th>Case</th>
<th>Specific Cases</th>
<th>Network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>UMTS</td>
<td>Wireless data network</td>
</tr>
<tr>
<td>Case 2</td>
<td>UMTS+WiMAX</td>
<td>Mobile network</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Satellite network</td>
</tr>
<tr>
<td>Case 3</td>
<td>WiMAX+UMTS</td>
<td>Pre-installed WiMAX</td>
</tr>
<tr>
<td>Case 4</td>
<td>WiMAX STAT.</td>
<td>Pre-installed WiMAX</td>
</tr>
<tr>
<td>Case 5</td>
<td>WiMAX</td>
<td>Full WiMAX network</td>
</tr>
<tr>
<td>Case 6</td>
<td>SAT. 1 WAY</td>
<td>1 way satellite</td>
</tr>
<tr>
<td>Case 7</td>
<td>SAT. 2 WAY</td>
<td>2 way satellite</td>
</tr>
</tbody>
</table>

**IBCN**

**IBCT**
Technology mapping

None - UMTS – HSDPA – WiMAX

2008
2009
2010
2011
2012

UMTS + WiMAX
<table>
<thead>
<tr>
<th>CapEx</th>
<th>Wireless data networks</th>
<th>Mobile networks</th>
<th>Satellite networks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Train equipment</td>
<td>Outdoor antenna</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Indoor network</td>
<td>+</td>
<td>+++</td>
</tr>
<tr>
<td>Network equipment</td>
<td>Trackside network</td>
<td>+++</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>NOC</td>
<td>+</td>
<td>+++</td>
</tr>
<tr>
<td>General costs</td>
<td>Helpdesk</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td></td>
<td>Sales (billing)</td>
<td>++</td>
<td>++</td>
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<tr>
<td></td>
<td>Marketing</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Operations</td>
<td>Maintenance and repair</td>
<td>+++</td>
<td>++</td>
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<tr>
<td></td>
<td>Network management</td>
<td>+</td>
<td>+++</td>
</tr>
<tr>
<td></td>
<td>License costs</td>
<td>+</td>
<td>+++</td>
</tr>
<tr>
<td>Network connection</td>
<td>Outdoor link</td>
<td>+</td>
<td>+++</td>
</tr>
</tbody>
</table>
Revenue schemes

- **Ticket types**
  - Prepaid cards per hour (e.g. hotspot service)
  - Monthly subscriptions

- **Ticket price**
  - Dependent on offered service: €2.9 – €3.9 (5 - 55 kbps)
  - Service of 30 kbps: Prepaid: €3.4 / Subscription: €18

- **Two revenue scenarios**
  - Both first and second class paying
  - First class free Internet, second class paying

⇒ Modal switch from 1st to 2nd class!!!
**NPV analysis** (10 years, 15% discount rate, 1st class free Internet)

30 kbps per individual user ≈ user experience of ±1 Mbps
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### Sensitivity results

<table>
<thead>
<tr>
<th>UMTS</th>
<th>-100%</th>
<th>-50%</th>
<th>0%</th>
<th>50%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandwidth per user</td>
<td>-94%</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Number of SIM cards per train</td>
<td>2%</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Second class adoption</td>
<td>1%</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Modal switch</td>
<td>1%</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Cellular bandwidth cost</td>
<td>1%</td>
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</table>

*Mobile networks*

*Due to the high bandwidth cost for UMTS*

### Full WiMAX network

More users + more bandwidth (less important with dedicated networks) = higher revenue

<table>
<thead>
<tr>
<th>WiMAX</th>
<th>-100%</th>
<th>-50%</th>
<th>0%</th>
<th>50%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Second class adoption</td>
<td>51%</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Bandwidth per user</td>
<td>30%</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Tariff per hour</td>
<td>-10%</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modal switch</td>
<td>-4%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leasing percentage poles</td>
<td>2%</td>
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</tbody>
</table>
Summary 1

When more bandwidth is guaranteed to the customer:

- **UMTS cases**
  - Only UMTS: Problems $\rightarrow$ No QoS
  - Combination with WiMAX: QoS can be guaranteed
  - Pre-installation WiMAX: more optimized network rollout

- **WiMAX case:**
  - Only interesting for large bandwidth

- **Satellite cases:**
  - UMTS as gap filler: bandwidth problems
  - 1Way Satellite: uplink bandwidth problems (UMTS)
  - 2Way Satellite: less dependent of bandwidth
Summary 2

- **Combination of technologies required**
  - Dense railway network: UMTS + WiMAX
  - Rural railway network: Satellite solutions

- **Business case**
  - Positive case in Belgium is possible
  - Influenced by many factors
    - User forecasting, rollout scheme, offered bandwidth
  - Business models
    - Role and participation of the partners important
Thank you!

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