QoS-enabled Internet-on-train network architecture: inter-working by MMP-SCTP versus MIP

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Overview

- Introduction
- Measurements
- Architecture
- MIP versus MMP-SCTP
- Conclusions and future work
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Introduction – Demands

- Need for broadband applications in car, train,…
  - Broadcast information (TV-like)
  - Interactive multimedia (videoconferencing, gaming, …)

- High density users who demand high bandwidth and high QoS
Introduction – Trends

- Internet on the train
  - Rising concept
  - Trials in several countries

- Deployment of new wireless technologies, but:
  - No complete coverage
  - Roaming is expensive
Introduction – Needs

- Need for an architecture that combines
  - Broadband access
  - Scalability
  - Seamless handover
  - Quality of Service guarantees
Introduction – Our work

- Comparison of throughput, delay and handover measurements of current wireless technologies
- Proposal of a new architecture to satisfy the needs of an internet-on-train network
- Comparison of two possible inter-working mobility solutions: Mobile Multi-Path SCTP (MMP-SCTP) and Mobile IP (MIP)
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Measurements

- Testing several deployed wireless technologies in Belgium: GPRS, EDGE, UMTS, HSDPA
  - Data throughput
  - Packet delay
  - Handover measurements

- Tests performed by car in December 2006
Measurements - Objectives

- Test data throughput
- Measure data packet delay variation
- Handover delays between base-stations and technologies
- Study the influence of speed on the above measurements
Measurements – Results

- **GPRS and EDGE**
  - Good coverage
  - GPRS suffers from a low bandwidth
  - EDGE does not support fast moving users

- **UMTS**
  - Several channels to be bundled for an acceptable bandwidth
  - Packet delay and base station handover are good and stable

- **HSDPA**
  - HSDPA allows fast link adaptations thanks to the TTI of 2 ms
  - HSDPA supports fast hybrid ARQ to keep packet delays low
Measurements – Results

- GPRS or EDGE are not usable as stable train-to-ground backhauls, but UMTS and HSDPA show much better behavior.

- Handover between systems can introduce packet loss and delay, which has an impact on the QoS of the passenger-applications.

- Need for a seamless mobility protocol which is able to hide handover delay and loss at the IP level.
Overview

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- Architecture
  - PDF
  - Mobility management
  - MIP
  - MMP-SCTP
- MIP versus MMP-SCTP
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Architecture

- Web Services
- Real Time Communication Services
- VPN Services
- Mobility Management
- Station hotspot
- Onboard
- Satellite
- Trackside
Architecture

Mobility Management CMS
- Data analysis
- QoS scheduler
- Buffer
  - Data divided among tunnels

Mobility Management Train
- Aggregation unit
- Buffer
- QoS scheduler
- Data analysis
  - Data partitioned in classes
  - Data from train passengers and crew

Gateway
- Data towards local train network
- Data from external users via NAT

QoS management
- Data analysis

Tunnel management
- Handover protocol
- Monitoring
  - Bandwidth quality, packet losses
- PDF
  - Command to set up/break down tunnel

Data plane
- Data from internet via NAT
- Data from external users via NAT

Control plane
Policy Decision Function
Decides which interface(s) should be used to connect the train with the corresponding access network(s)
Decision based on
- SNR, loss, traffic measurements
- GPS, speed and management info
- Load balancing and cost
Convey decision to Mobility Management Handover Protocol
Architecture – Mobility management

- Partly on the train and partly on the central management system
- Performs all mobility specific actions
- Two alternatives for the mobility management handover protocol:
  - Mobile IP (MIP)
  - MMP-SCTP.
- Both consider the train as a mobile router and the passengers as a mobile network
- User will not need a MMP-SCTP or MIP-aware device
Architecture – MIP

- The Home Agent resides in the Central Management System
- The Mobile Node is considered to be a mobile router with a mobile network of passengers
- No router advertisements
- Minimizing the actual handover delay by performing a MIP pre-registration
Architecture – MIP

- CMS
- Train home agent
- Internet
- Train
- Colocated mobile node
  - Colocated care-of-address: 203.168.68.33
  - Home address: 192.168.10.2
Architecture – MMP-SCTP

- **SCTP (Stream Control Transport Protocol)**
  - Reliable transport protocol on top of a potentially unreliable connectionless packet service
  - Selective acknowledgements (SACKs)
  - Multihoming

- **ADDIP extension**
  - Known as mSCTP (mobile SCTP)
  - Support dynamic address reconfiguration

- **Mobile Multi-path SCTP (MMP-SCTP)**
  - Uses multiple links simultaneously for data transfer
  - Seamless handover for mobile hosts that are roaming between IP networks
Dia positive 20

slide vervangen door figuur

Daan Pareit, 31/05/2007
Architecture – MMP-SCTP

CMS

Internet

210.115.1.0

220.166.2.1

Train
slide vervangen door figuur
Daan Parelt; 31/05/2007
Overview

- Introduction
- Measurements
- Architecture
- MIP versus MMP-SCTP
  - Overhead
  - TCP performance without handover
  - UDP performance with predicted handover
  - UDP performance with unpredicted handover
- Conclusions and future work
Both protocols involve overhead in order to ensure transparent mobility to the user.

The passengers IP packets are encapsulated in MIP or MMP-SCTP packets.
Theoretical overhead calculation

- The ratio of the extra bits sent (the MIP or MMP-SCTP headers) to the total of bits sent without a mobility protocol.

MMP-SCTP has more overhead than MIP.
MIP versus MMP-SCTP – Testbed
MIP versus MMP-SCTP - TCP performance without handover

Moving average of the throughput for TCP-traffic comparison between MIP and MMP-SCTP without handover
MIP versus MMP-SCTP - UDP performance with handover

- Iperf generates downlink UDP traffic towards passenger at 192 kbit/s with payload of 1300 bytes
- Handover simulation between satellite and HSDPA
- MIP results:
  - No retransmissions
  - All packets arrive in order
  - Inter-arrival time peaks and stabilizes again
- MMP-SCTP results:
  - No retransmissions
  - All packets arrive in order
  - Inter-arrival time peaks and stabilizes again
UDP performance with predicted handover for MIP
UDP performance with predicted handover for MMP-SCTP
UDP performance with unpredicted handover for MMP-SCTP

Sequence graph and Interarrival Time of an UDP CBR 192 kbps stream over MMP-SCTP
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Conclusions and future work

- Satellite, GPRS, UMTS, EDGE and HSDPA are available but a higher level protocol is needed
- Proposed architecture can satisfy the needs for an internet-on-train network
- MIP versus MMP-SCTP
  - MIP and MMP-SCTP are both able to handle predicted handovers seamlessly
  - MMP-SCTP has a higher overhead than MIP
  - MMP-SCTP has built-in reliability which is beneficial in case of abrupt handover
Conclusions and future work

- Still room for improvement of both protocols
- Future work will focus on PDF which will determine the optimal moment for handover in order to minimize
  - Handover delay
  - Packet loss
  - Network load
Thank you for your attention

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