Delay Tolerant Streaming

Contradiction, Fiction, or Science?

Vera Goebel & Thomas Plagemann

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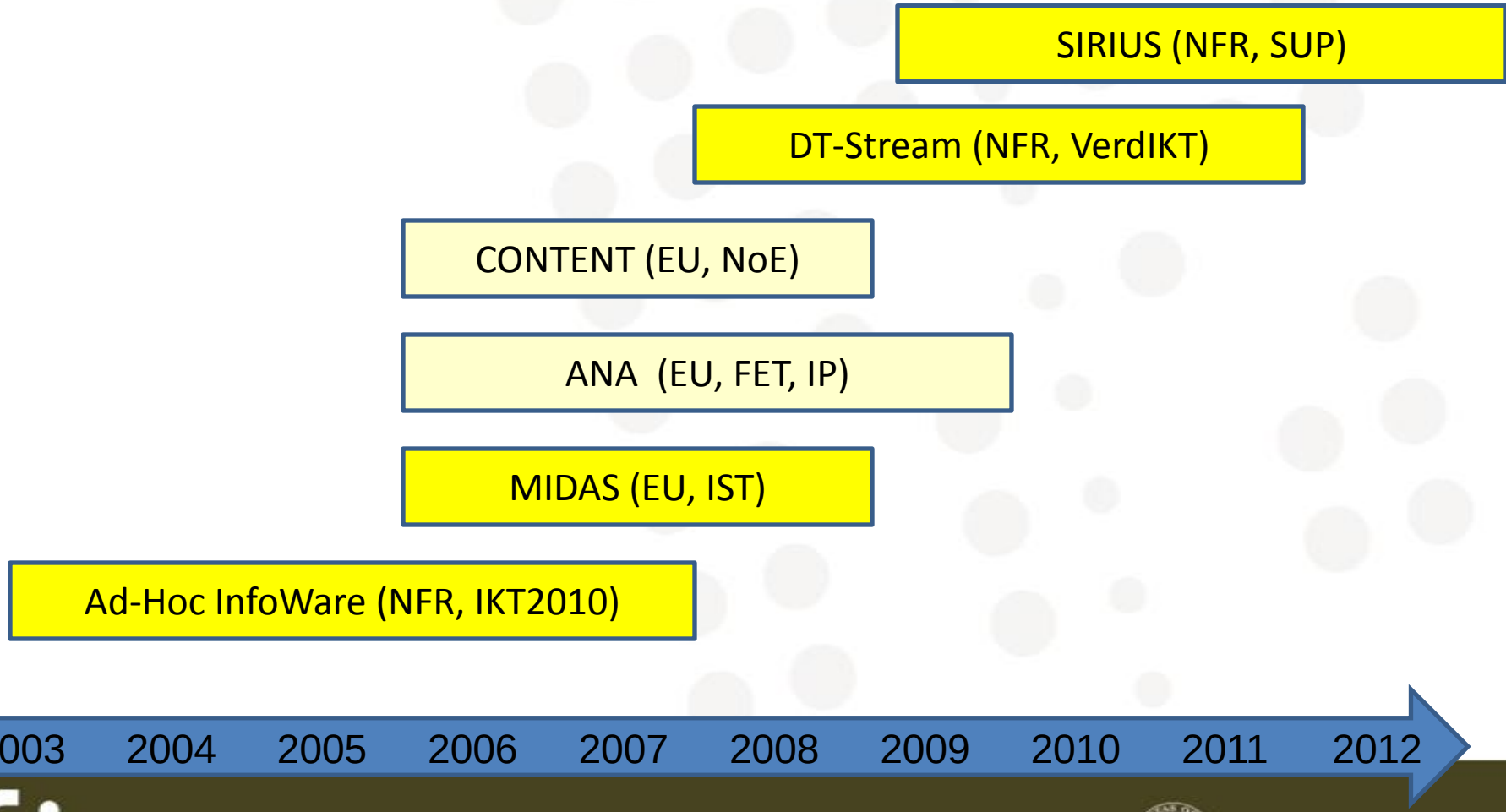
Larger Projects in the DMMS group

+ pre-project with Research Intitute of Vienna Red Cross



Acknowledgement to our Funding Agencies

- Ad-Hoc InfoWare:
  - Norwegian Research Council, IKT2010 Program
  - Project Nr. 152929/431
- DT-Stream:
  - Norwegian Research Council, VerdIKT Program
  - Project Nr. 183312/S10
- CONTENT:
  - EU 6th Framework IST
  - Contract no. IST-FP6-0384239

About us…..

- Collaboration between University of Oviedo and University of Oslo
  - Visits from Xabiel García Pañeda
  - Erasmus Master Students worked towards very first prototype: Sergio Cabrero Barros, Francisco Javier Campa Lus, Jorge Suárez Rivaya
- DT-Stream received funding:
  - PhDs: Morten Lindeberg, Stein Kristiansen, Daniel Rodriguez
  - PostDoc: Ovidiu Drugan
- Xabiel received funding in Asturias:
  - PhD: Sergio Cabrero Barros
- Active Master Students:
  - Jorge Sentis, Lars Olav Dybsjord, Cristobal Emilio Dabed, Jon Anders Skorpen, Kim Sørhus

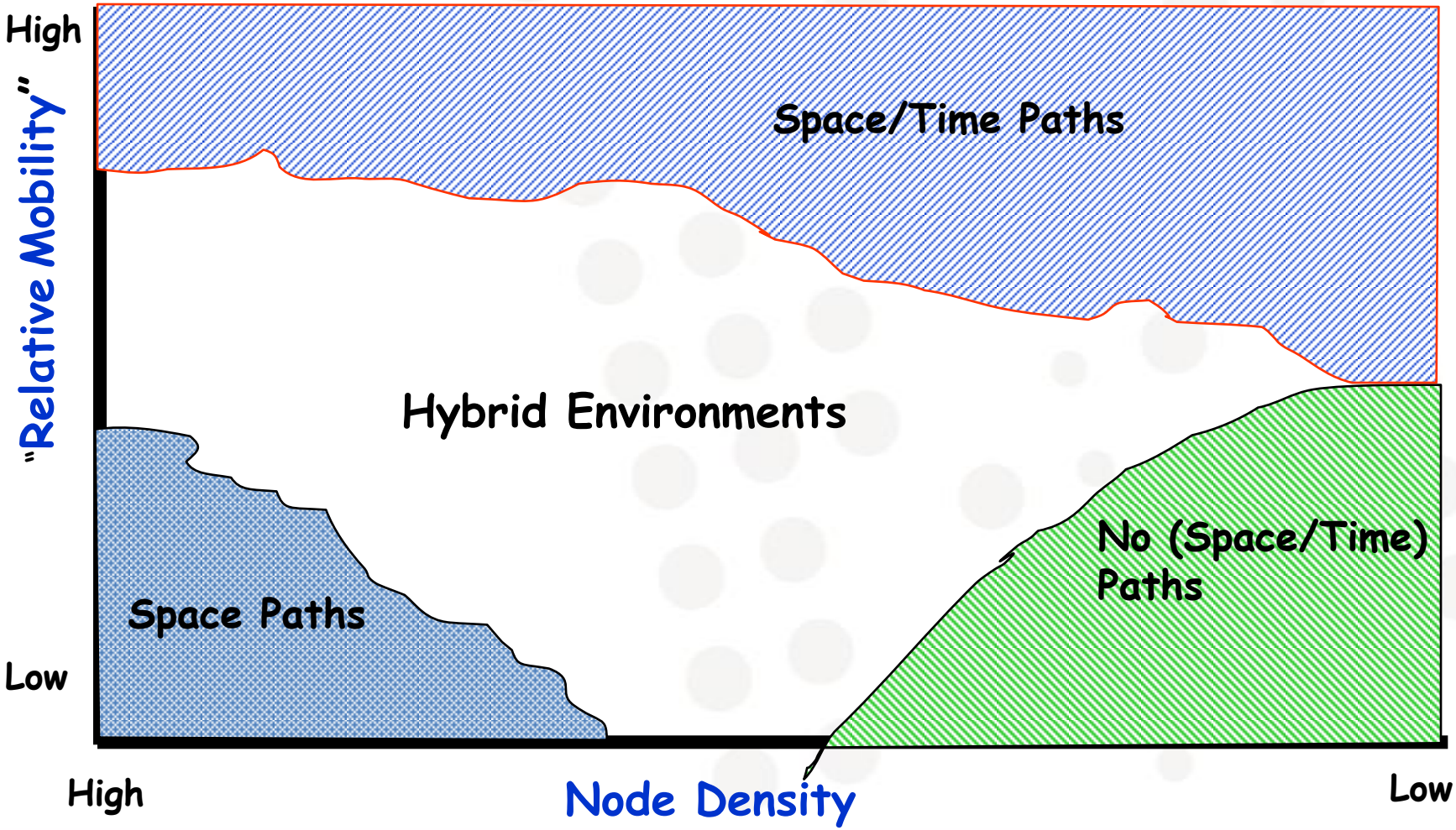
Outline

- Background
  - Application domain
  - Delay Tolerant Networking
  - Putting it together
  - DT-Stream project
- Research ideas and approach
  - Synchronous and asynchronous modes
  - Overlay
- Preliminary results
  - Streaming on small mobile devices
  - MOMENTUM → Sergio
  - Red Cross traces
- Conclusions

Application Domain

[Source: applica.no]

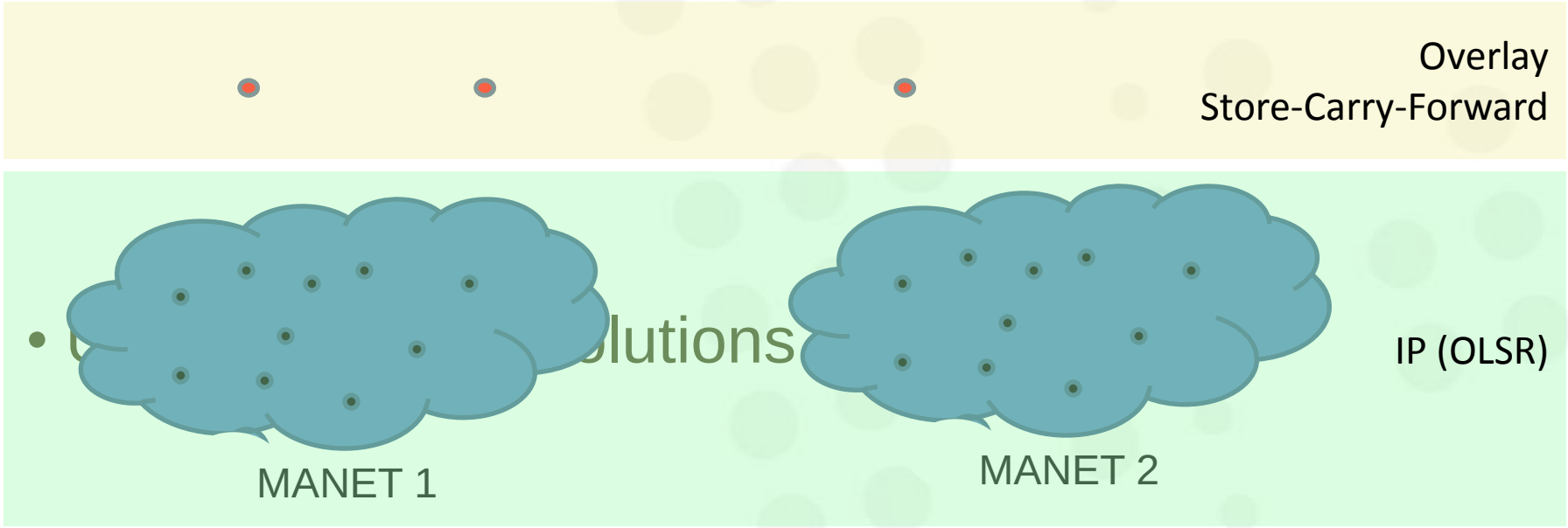
The Mobile Wireless Space



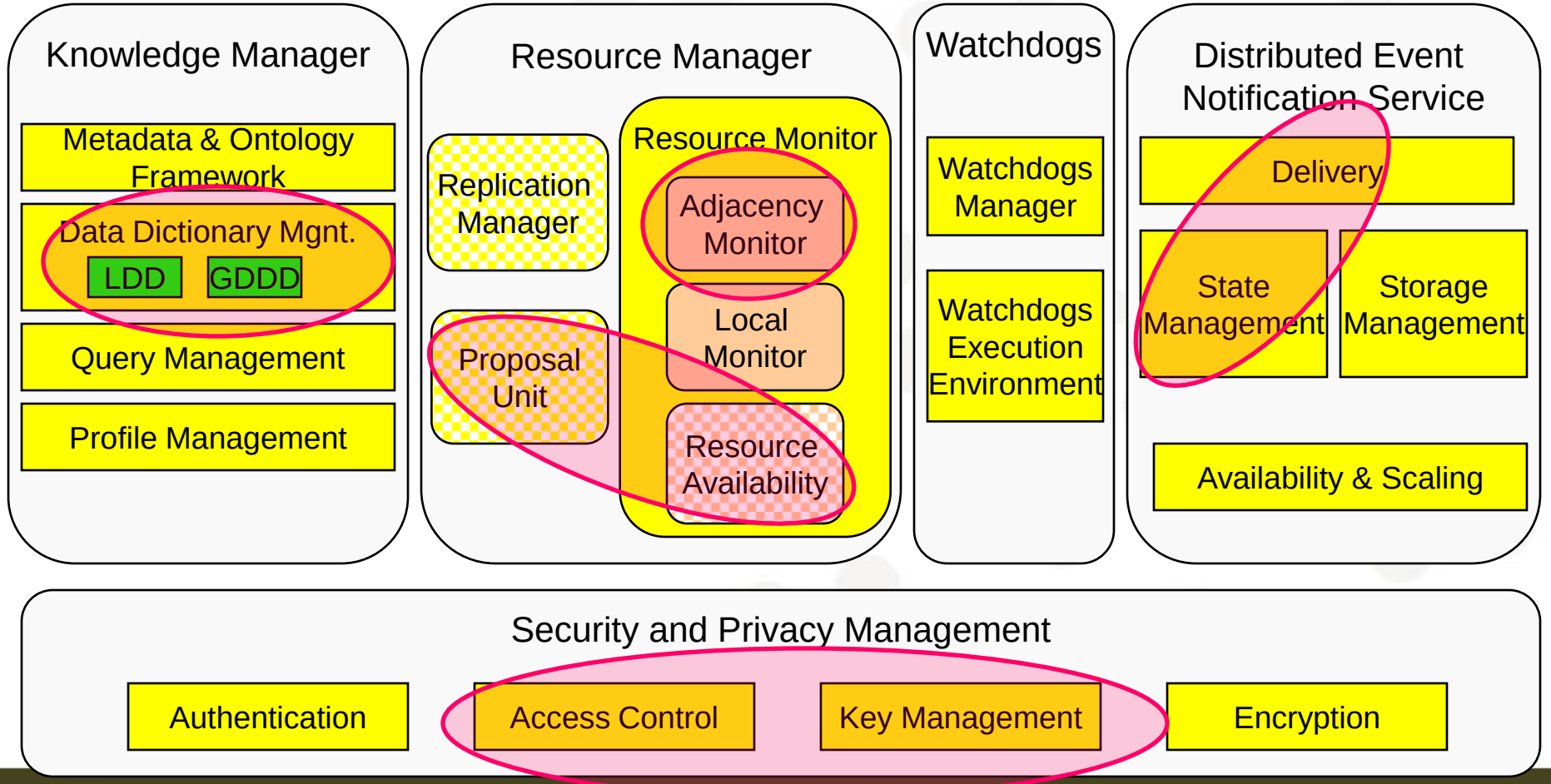
From M. Ammar: Key Note at CoNext 2005

Idea and Approach in Ad-Hoc InfoWare

- Combine Mobile Ad-Hoc Network solutions with Delay Tolerant approaches



Ad Hoc InfoWare – Overview



DT-Stream

Can we do video/audio streaming over such networks?

DT-Stream

- Pre-project:
  - 2007 four Master Students
- Funding:
  - Norwegian Research Council (3PhDs & 1 PostDoc, +)
  - Spanish Governement (1PhD)
- Project participants:
  - University of Oslo
  - University of Oviedo
  - Paradial

DT- Stream Goals

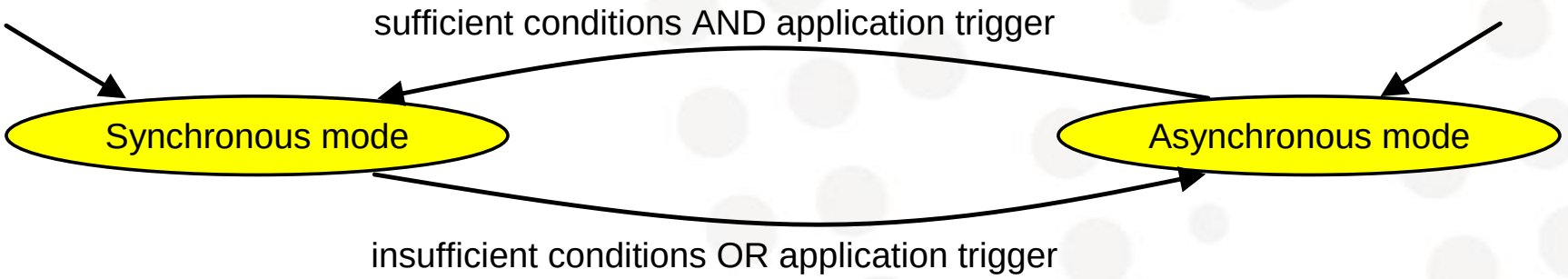
- Delay tolerant streaming applications that do not break when network partitions occur, but instead adapt their functionality, and which seamlessly proceed when connectivity is back
- A self-adaptive overlay that caches AV data at selected nodes to increase the resilience and performance of the AV services
- Autonomic resource management to discover, monitor and manage resources through distributed admission control and multi-path routing protocols.

Basic Approach

	Insufficient resources	Temporary sufficient resources	Sufficient resources
No connectivity	Not solvable	Reduce problem	Reduce problem
Temporary connectivity	Reduce problem	Develop new solutions	Develop new solutions
Full connectivity	Reduce problem	Develop new solutions	State-of-the-Art

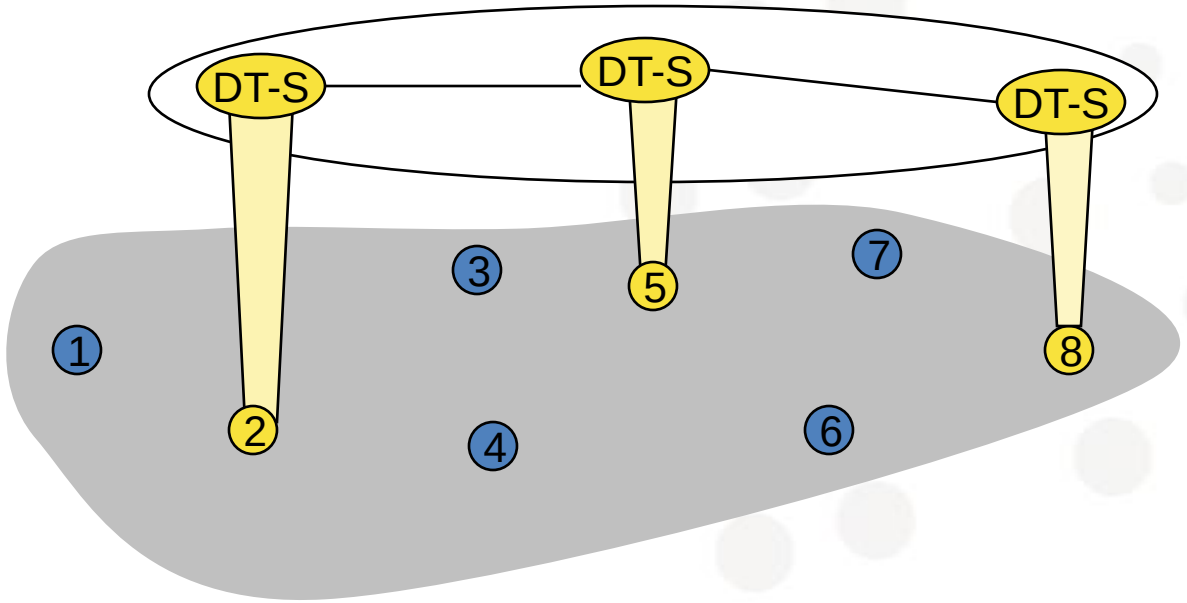
Synchronous and asynchronous mode

- Delay Tolerant AV Streaming Applications



Overlay

- Adaptive Overlay for Delay Tolerant Streaming



Feasability Study for DT-Stream

Can mobile devices be used for video streaming in Manets?

Master Student Magnus Halvorsen at the University of Oslo
Supervisors: Thomas Plagemann & Matti Siekkinen

Transparencies provided by Magnus – Thanks!

Nokia Internet Tablets

- N770
  - CPU: 252MHz TI OMAP 1710
  - Display:
    - 800x480x16
    - touch-screen
  - Connectivity:
    - 802.11g WLAN
    - Bluetooth 1.2
  - Memory and storage:
    - 64 MB RAM
    - 128MB flash
    - up to 1GB RS-MMCMemory and storage:
- N800
  - CPU: 320 MHz TI OMAP
  - Display:
    - 800x480x16
    - touch-screen
  - Connectivity:
    - 802.11g WLAN
    - Bluetooth 2.0
  - Memory and storage:
    - 128 MB DDR DRAM
    - 256MB flash
    - up to 8GB microSD

Experiment video clips

- MPEG-1, MPEG-4
- 1000, 500, 200 Kbps
- Low action and high action clip

Choice of video clip parameters

- Resolution
  - Small screen size
  - 800x480 (15:9) screen resolution
  - Full screen playback
  - 400x240 and 200x144 pixels scales well
- Bandwidth
  - 1000, 500 and 200 Kbps
  - High to relatively low B/W requirements
  - Related to choice of resolution
- Encoding
  - MPEG-1 and MPEG-4 ASP
  - Widespread
  - Supported by both server and client
- Clip content
  - Low-action clip
  - High-action clip
  - To see impact of clip content on results
- No audio
  - Focus on video stream

Video experiments

- Local playback on the Nokia 770
- One-hop streaming, Nokia 770 to Nokia 770
- Multi-hop streaming with 3 Nokia 770s, using OLSR
- Local playback on the N800

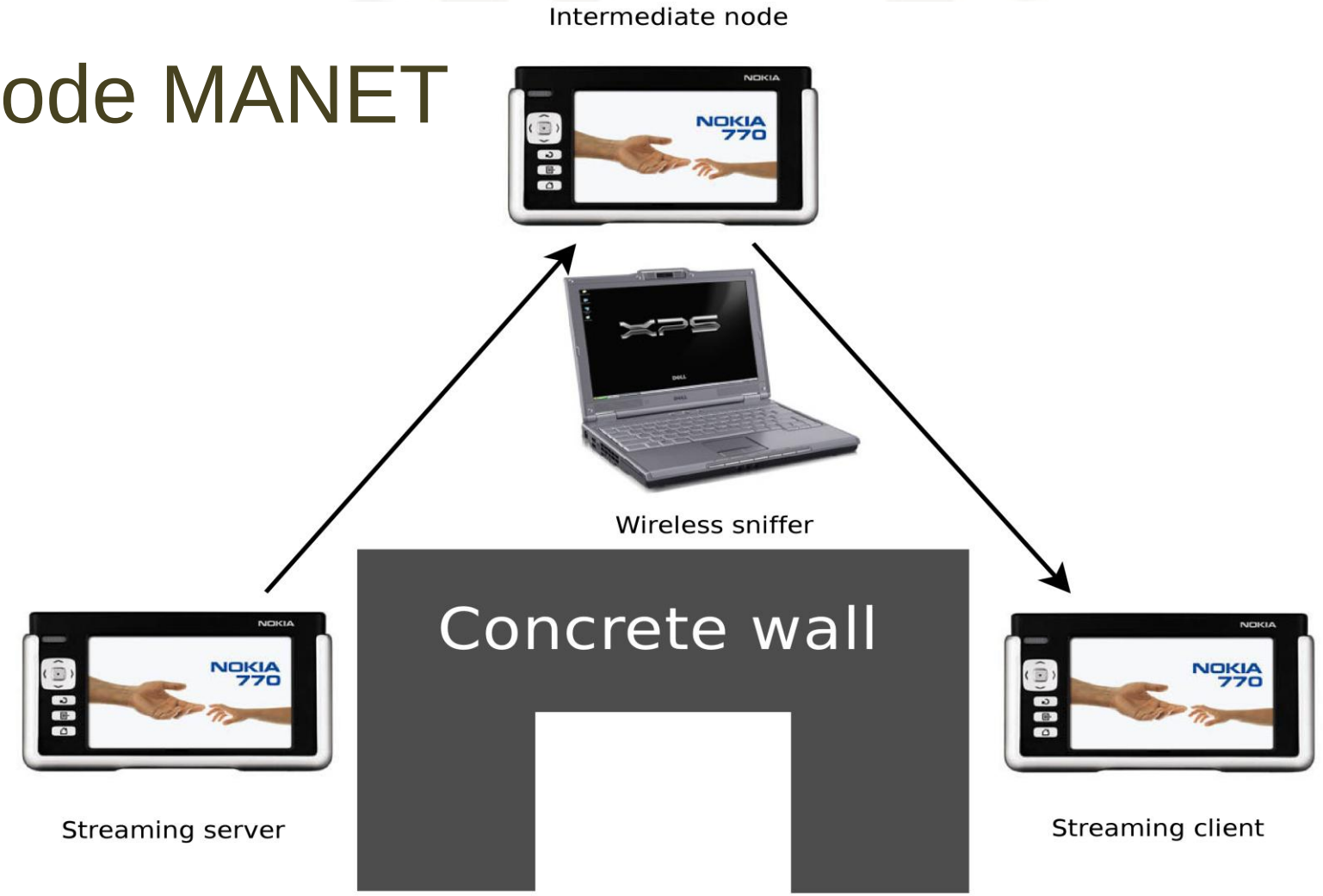
Node-to-node streaming setup

Wireless sniffer

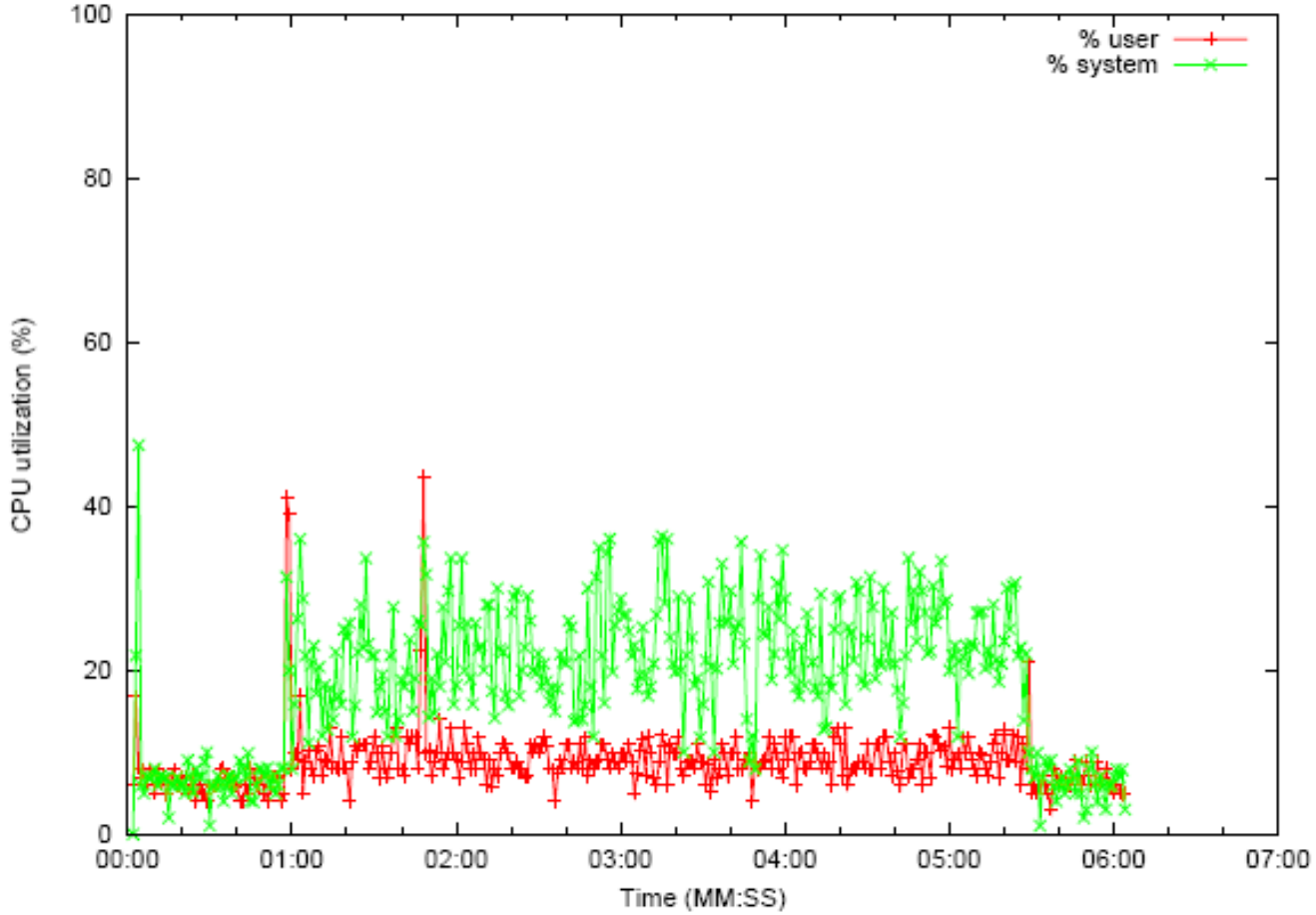
Streaming server

Streaming client

3-Node MANET

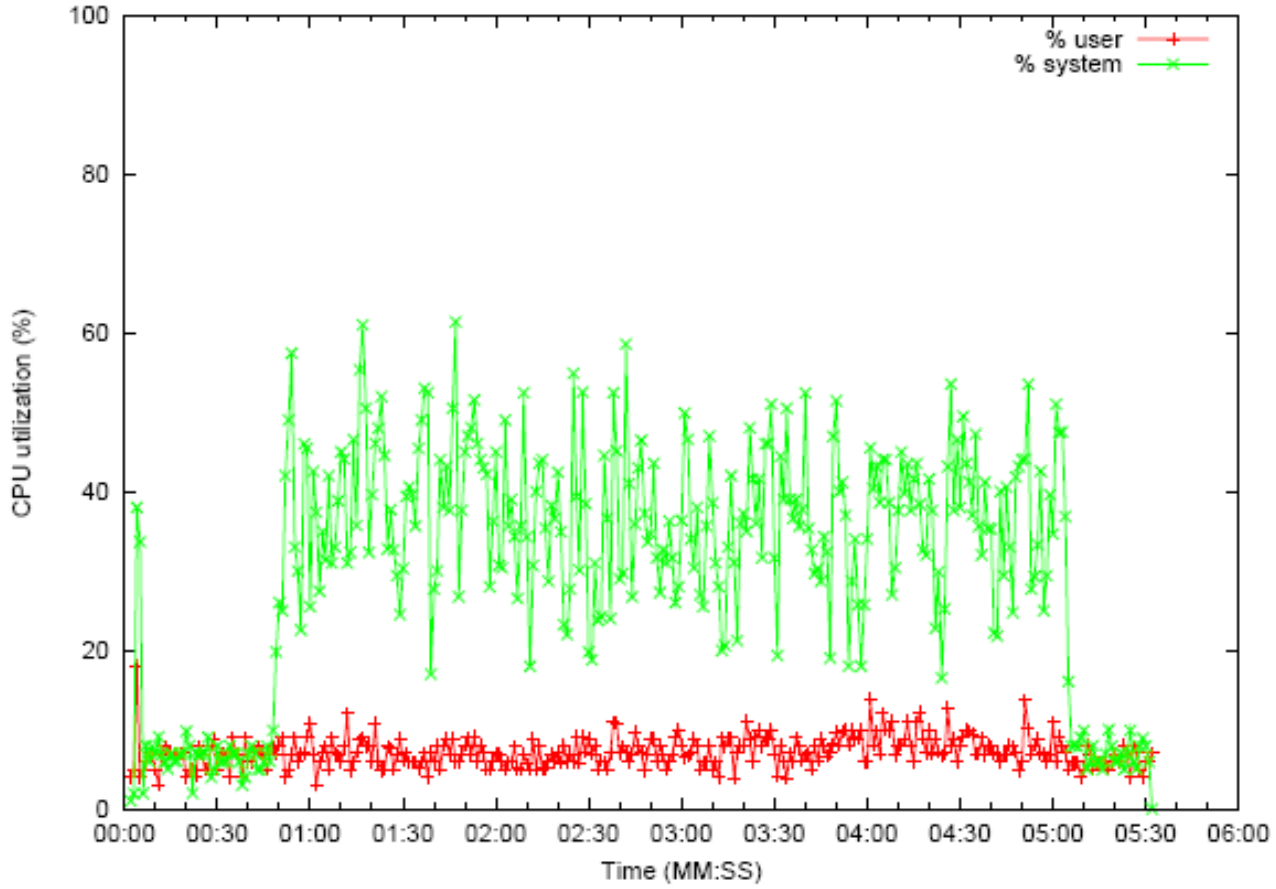

Intermediate node
NOKIA
770
XPS
Wireless sniffer
Concrete wall
NOKIA
770
Streaming server
NOKIA
770
Streaming client

CPU Utilization at Server



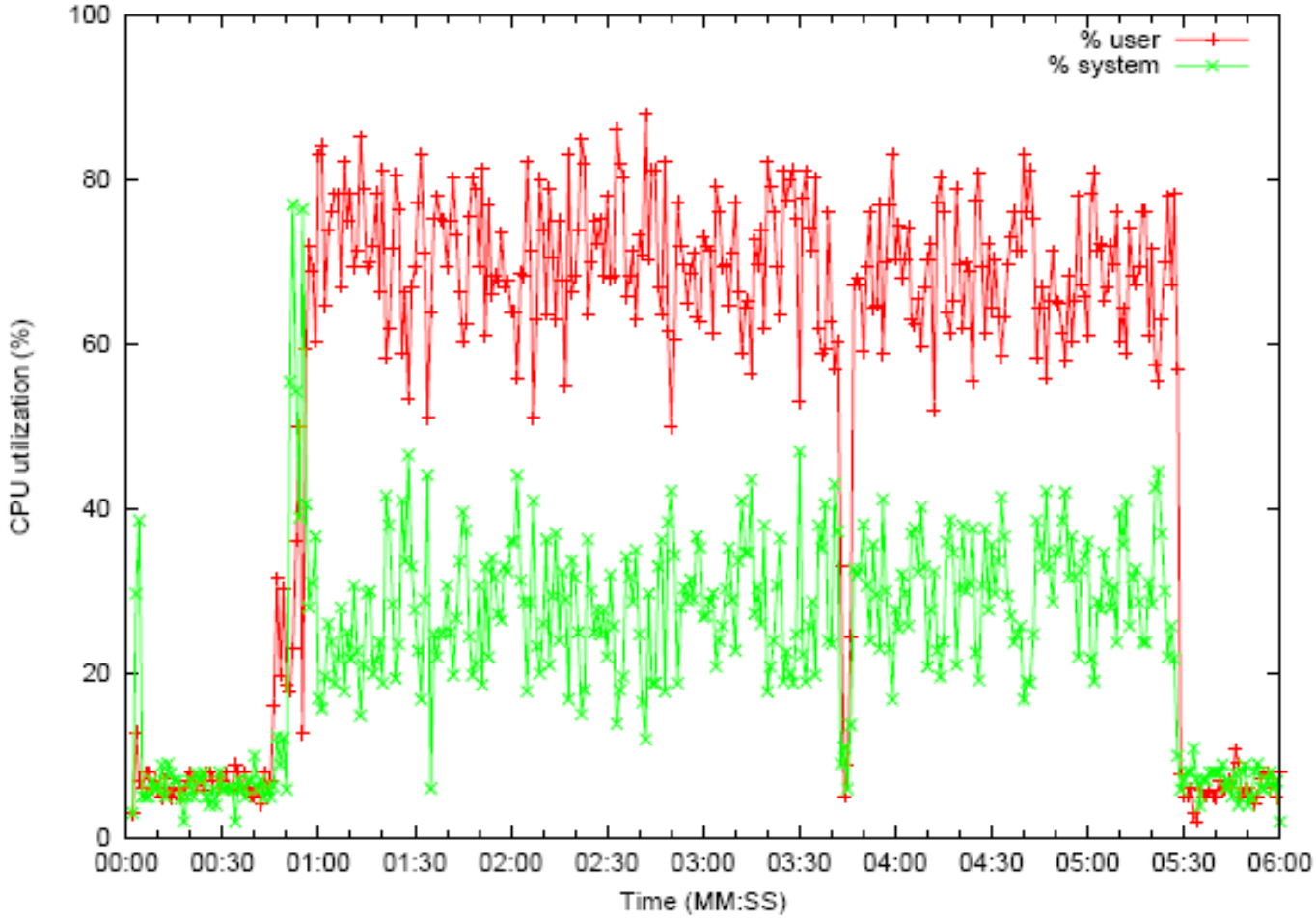
Action clip
400x240
1000Kbps
MPEG-4

CPU Utilization at Forwarding Node



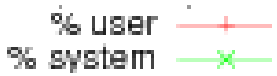
Action clip
400x240
1000Kbps
MPEG-4

CPU Utilization at Client

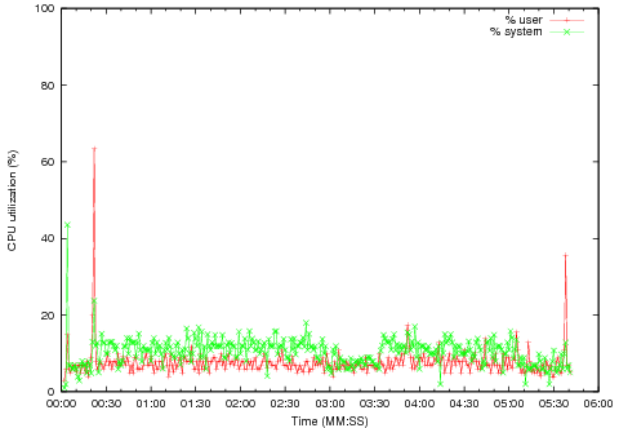


Action clip
400x240
1000Kbps
MPEG-4

Multi-hop streaming – CPU utilization 240x144 200 Kbps MPEG-4 action clip



Server node

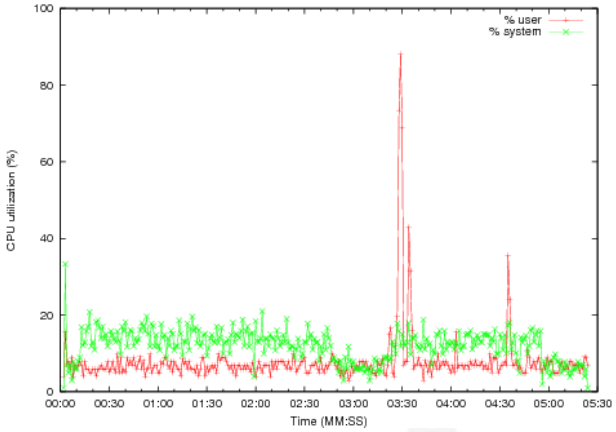


User CPU: ~ 8 %

System CPU: ~ 10 %

(I/O wait CPU: ~ 20 %)

Intermediate node

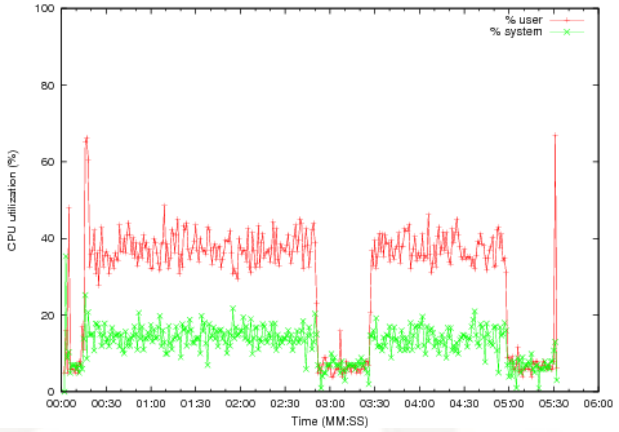


User CPU: ~ 8%

System CPU: ~ 10 %

(I/O wait CPU: ~ 5 %)

Client node



User CPU: ~ 40 %

System CPU: ~ 15 %

(I/O wait CPU: ~ 5 %)

CPU utilization

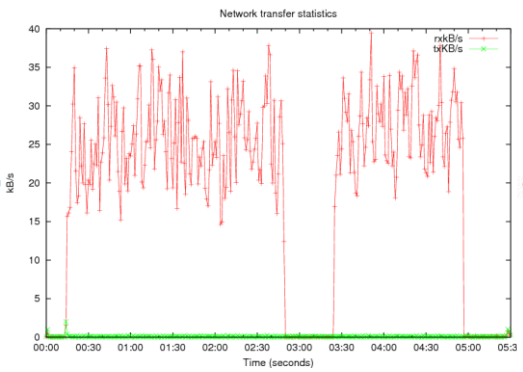
- CPU utilization is obviously an issue
  - Particularly on the client side
  - But streaming adds little processing overhead on the client
- Resource consumption on intermediate node increases more than on server, when video bit rate increases
- Perceived quality of the video stream was the same in the node-to-node and multi-hop scenarios
- 240x144 500 Kbit MPEG-4 video seems to represent a good tradeoff between resource requirements and quality on the Nokia 770

Advantages of cross-layer monitoring - case study

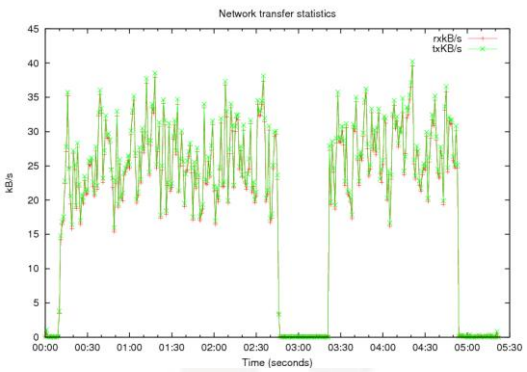
1. Visible effect
   - Playback freezes then resumes after 30 seconds
2. CPU utilization
   - Drops at all nodes (as previously seen on earlier slide)
3. Network transfer statistics
   - Client node halts reception
   - Intermediate node halts reception and transmission
   - Server halts transmission
4. OLSR logs
   - Route breaks between intermediate and client node
5. Wireless link statistics
   - Drop in link quality at intermediate node
6. Conclusion: Playback froze as a consequence of the route breaking between the intermediate and client nodes due to low quality of the wireless link

Advantages of cross-layer monitoring – finding the cause

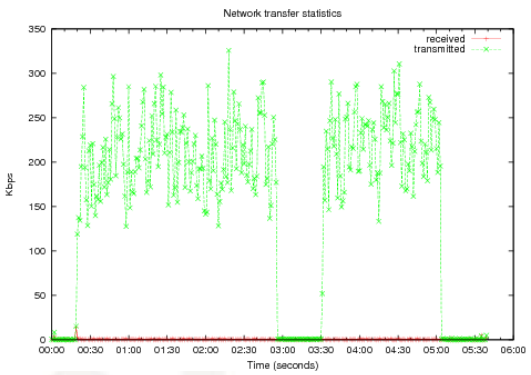
Network transfer statistics



Client node



Intermediate node



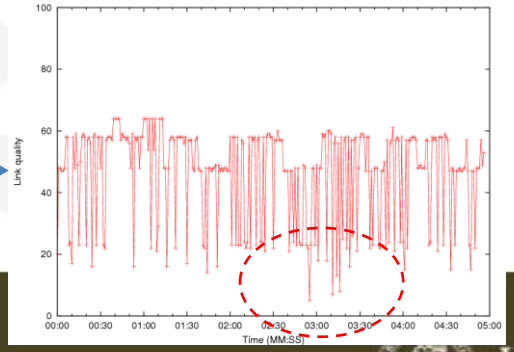
Server node

OLSR log

```
--- 03:56:46.85 ------------------------------------------------- LINKS

IP address       hyst   LQ     lost   total  NLQ    ETX
10.0.0.3         0.250  0.000  0      0      0.000  0.00

--- 03:56:46.85 ------------------------------------------ NEIGHBORS

IP address       LQ     NLQ    SYM    MPR    MPRS  will
10.0.0.3         0.000  0.000  NO     NO     NO    3

--- 03:56:46.85 ------------------------------------------ TOPOLOGY

Source IP addr   Dest IP addr      LQ     ILQ    ETX
10.0.0.3         10.0.0.2          0.000  0.000  0.00
10.0.0.3         10.0.0.1          0.000  0.000  0.00
HYST[10.0.0.3] HELLO timeout 0.125

--- 03:56:49.21 ------------------------------------------------- LINKS

IP address       hyst   LQ     lost   total  NLQ    ETX

--- 03:56:49.21 ------------------------------------------ NEIGHBORS

IP address       LQ     NLQ    SYM    MPR    MPRS  will

--- 03:56:49.21 ------------------------------------------ TOPOLOGY
```

Client node

Link quality



Intermediate node

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Magnus' Results and Insights

- Successfully created a working MANET streaming solution for Nokia 770
- Performed cross-layer monitoring of the solution
- Created a live test-bed for wireless, multi-hop streaming
- Playback consumes large amount of resources on client
- Intermediate node consumes twice as much CPU resources as server
  - both receiving and forwarding
- Server supports 4-5 simulatenous 1000 Kbps streams

Towards real-world mobility traces

- Collaboration with Research Institute of the Vienna Red Cross late 2007 and early 2008
- PDA's equipped with wireless connectivity and GPS technology
- Log traces / movements for MANET simulations

Conclusions

- Streaming in real MANETs is possible, but requires strong resource management solutions
- Overlay structures can combine MANETs and DTNs and be used for streaming
- How to do realistic simulation
  - ”*Ongoing*” work collect traces from real emergency and rescue operations together with Vienna Red Cross
- A lot of research needs to be done .. but the project *just* started
- **Do we see meaningful collaborations under the CONTENT hood++?**