RVS Seminar
Adaptive Transmission Over Multipaths

ATOM

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Outline

> Motivation
> Key idea
> Related work
  — Multi-path routing protocols
  — Routing metrics
  — Multi-stream coding
> Adaptive Transport Over Multipaths (ATOM)
> Next steps
> Conclusions
> Questions
Wireless Mesh Network (WMN)
WMN for Real Time Applications

> WMN

- Robust, redundant communication infrastructure
- Communication possibilities even in situations where certain systems (e.g. GSM) are overloaded
  → VoIP + video conferencing during critical situations (emergency communications)

- Disadvantage
  - Route quality may unpredictable vary because of unreliable / erroneous wireless medium
    → route breaks, high delays
  
  ➡ Deployment of real-time applications like VoIP (short delays, moderate packet loss) is a challenging task

➡ Possible solution: using path diversity (multi-path routing) and multi-stream coding
Key Idea: Multi-Path Routing and Multi-stream Coding

> Transmission over multiple paths can compensate the dynamic and unpredictable nature of the wireless medium
  — Different paths have different error characteristics, different delays etc.
> Encoding in multiple streams
> Individual streams are transmitted over independent paths
Path Diversity: Multi-Path Routing Protocols

> Based on AODV [1]:
  - AOMDV [2]
  - AODVM [3]
  - Node-Disjoint Multipath Routing (NDMR) [4]
  - Similar Node-Disjoint Multipath Routing (SNDMR) [5]
  - AODV-BR [6]
  - MP-AOMDV [7]

> Based on DSR [8]:
  - Split Multi-Path Routing (SMR) [9]
  - Multi-Path DSR (MP-DSR) [10]
  - Multipath Source Routing (MSR) [11]

> CacHing And Multipath routing Protocol (CHAMP) [12]

> Multipath Associativity Based Routing (MPABR) [13]
Routing Metrics

> Most existing routing protocols base on simple hop count metric
> Problem: Incorrect assumption that links either work or not
  - packet loss ratio
  - bandwidth (transmission rates not considered)
  - (self-)interference (inter-flow, intra-flow)
  - varying delays for different links

> Other metrics
  - Expected transmission count (ETX) [14]
  - Expected transmission time (ETT) [15]
  - Weighted Cumulative Expected Transmission Time (WCETT) [15]
  - Metric of Interference and Channel-Switching (MIC) [16]
  - iAWARE [17]
Multipath Routing with Enhanced Metrics

> Multiple Paths
  
  — Minimized inter-flow interference between the selected paths
  
  — „Inter-Path“ interference has to be considered during path setup
    
    - adds neighboring links with possible interference, even normally there is no traffic on the links (planned part of a multi-path route!)
  
  — node-disjoint paths (?)
Coding: Layered Coding

- Layered Coding
  - Lena coded with DCT (Discrete Cosinus Transformation)

- Base layer + multiple enhancement layers
- Base layer is required for reconstruction!
Coding: Multi-Description Coding (MDC)

> Each stream is sufficient for an acceptable quality.
> Multiple streams enhance the quality.
Coding: MDC Lena Example

> Input image

> Encoding with 4 MDC streams
Coding: MDC Lena Example

> Input image

![Input image](image1)

Output image

![Output image](image2)

1 stream received

> Encoding with 4 MDC streams

![Encoding with 4 MDC streams](image3)
Coding: MDC Lena Example

> Input image

![Input image](image1)

> Output image

![Output image](image2)

> Encoding with 4 MDC streams

![Encoded image](image3)
Coding: MDC Lena Example

> Input image

![Input image](image1.png)

Output image

![Output image](image2.png)

2 streams received

> Encoding with 4 MDC streams

![Encoded image](image3.png)
Coding: MDC Lena Example

> Input image

![](image1.jpg)

> Output image

> Encoding with 4 MDC streams
Coding: MDC Lena Example

- Input image

- Output image

- 3 streams received

- Encoding with 4 MDC streams
Coding: MDC Lena Example

> Input image

> Encoding with 4 MDC streams

Output image
Coding: MDC Lena Example

> Input image

[Input image]

Output image

4 streams received

> Encoding with 4 MDC streams
Adaptive Transport Over Multipaths (ATOM)

ATOM aware Application

Encoding Plugins:
- SDC Encoding
- MDC Encoding

Decoding Plugins:
- SDC
- MDC Decoding
- Playout scheduler

ATOM Controller

Path Allocator

Multi-Path Routing

HSA

MMS

Application

Transport

Internet

Network

control

multiple streams

signalling

monitoring

active measurements

Thomas Staub, December 19th, 2007
ATOM Architecture: System Components

> ATOM aware application
  - Examples
    - Video conferencing
    - VoIP
  - ATOM API
    - Available codecs, coding options (→ATOM)
    - Selected encoding, number of streams (←ATOM)
    - Quality feedback (→ATOM)

> History and Statistical Analyser (HSA)
  - Robustness information of individual paths
    - Stability during the last week, days, hours, minutes
    - Assign values to routing table entries
  - Discovery of regularity, periodicity (bandwidth, outages, delays)
ATOM Architecture: System Components

> Monitoring and Measurement System (MMS)
  — Active measurement of network conditions
  — Monitoring of transmission (feedback)
> Multi-path routing
  — including new metrics based on iAWARE
  — informs ATOM controller about available paths
> Path Allocator
  — Allocates the streams to the paths according to ATOM controller
> End-to-end signalling
  — Application legacy signalling
  — Signalling using NSIS (?)
  — Informs destination about used encoding, number of streams
ATOM Architecture: System Components

ATOM Controller

- Gathered control data
  - Available encodings from application
  - Robustness info from HSA
  - Paths available from multi-path routing / HSA
  - Current network conditions from MMS

- Decision on
  - number of paths searched
  - encoding algorithm (MDC or LC)
  - number of streams
  - mapping of streams to paths

- Dynamic adaptation
  - MMS notices significant changes either by active (network probes) or passive measurements at the destination
Next Steps

> Detailed specification of ATOM
> Implementation of ATOM in Omnet++
  — Multi-channel support
  — Multi-path routing
  — Enhanced metrics
  — ATOM components
> Simulations and evaluations (multi-path routing protocols, metrics)
> Evaluations of regularities / periodicities in real world wireless traces
  — RAWDAD crawdad.cs.dartmouth.edu
  — MIT roofnet traces
Conclusions

> Real-time applications in WMNs are challenging

> **ATOM** architecture provides a solution based on
  – Multi-path routing
  – Multi-stream coding
Questions
Holiday Gift Ideas
For the Budget-Conscious Grad Student

- Recycle old lab equipment
  - it’s a what?
  - a multi-channel laser spectrophotography tissue analyzer!

- Put that English degree to good use
  - a collection of your poems.
  - how thoughtful.
  - again.

- Give the gift of Science
  - it’s alkali hydrolized sodium tallowate.
  - uh...
  - i made you soap.

- Let them know you care.
  - “another year of free computer tech support.”
  - you’re welcome.
Adaptive Transport Over Multipaths (ATOM)

References: Multipath Routing


References: Multipath Routing


References: Routing Metrics


>[16] Y. Yang, J. Wang, and R. Kravets, “Designing routing metrics for mesh networks,” in First IEEE Workshop on Wireless Mesh Networks (WiMesh), (Santa Clara, CA, USA), September 26 2005. (MIC)