Media-Aware Network Elements on Legacy Devices

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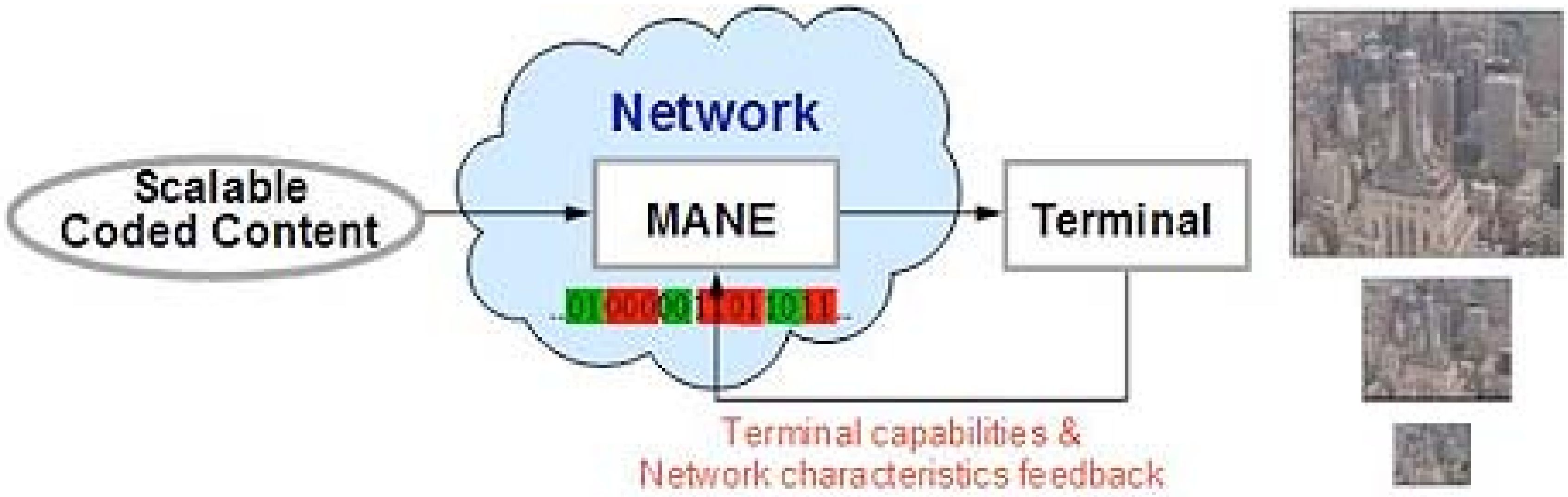
Outline

- Motivation and Introduction
- List of Technologies
- Architecture and Performance Evaluations
- Demo Video
- Conclusions / References

Motivation and Introduction

- Adaptation of an SVC bitstream
  - Achieved by removing certain NALUs → filtering of NALUs
  - Steered by a (TID, DID, QID) tuple → filter criteria
  - Computationally cheap (compared to transcoding etc.)
- Idea
  - Perform real-time in-network adaptation of the SVC bitstream on an ordinary, low-cost WiFi router
  - Media-aware Network Element (MANE)
- Applications of in-network adaptation
  - Cross-layer adaptation on the access point
  - Adaptation for different end-devices

Media-aware Network Element



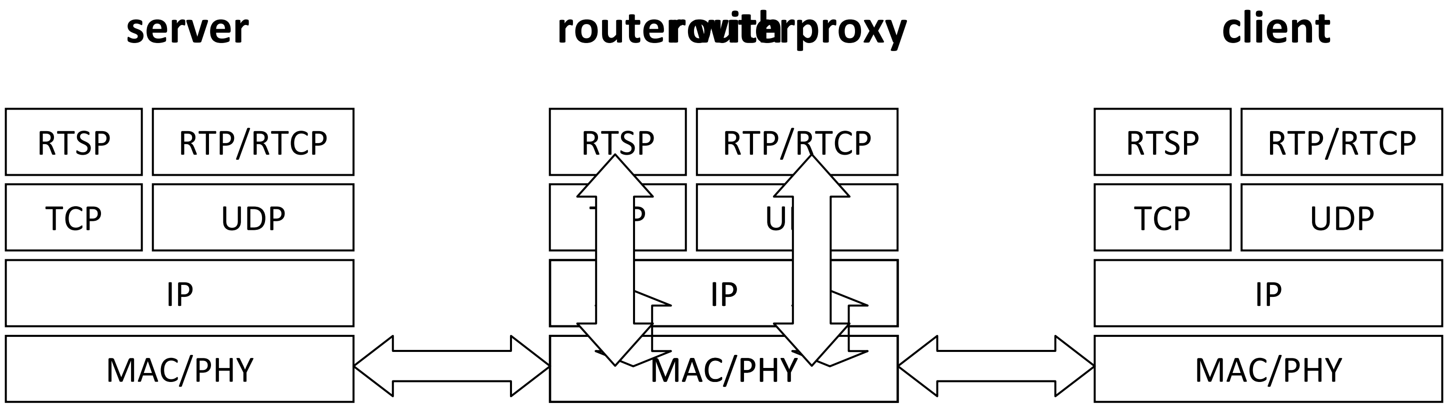
On-the-fly adaptation of scalable coded video content in a media-aware network element (MANE).

Source: http://ip.hhi.de/imagecom_G1/savce/

List of Technologies

- Scalable Video Coding (SVC)
- Real-time Streaming Protocol (RTSP)
  - Establishing and controlling the streaming session
  - VCR-like control of the streaming (Start, Stop, Pause)
- Real-time Transport Protocol (RTP)
  - Encapsulates the video and/or audio content
  - Mostly used on top of the unreliable UDP protocol
  - Offers sequence number, timestamps for syncing the playback
  - Generic header with content-specific payload format (AVC, SVC, …)

Proxy Approach



- Proxy on network device between client & server
  - Intercepts the RTSP / RTP communication
  - Proxy is transparent for the client
  - Acts as client for initial server and as server for the client
- Implications
  - Proxy has to modify parts of the request (e.g. port numbers)
  - Proxy can then adapt the SVC video stream carried over RTP

Proxy Approach (cont'd)

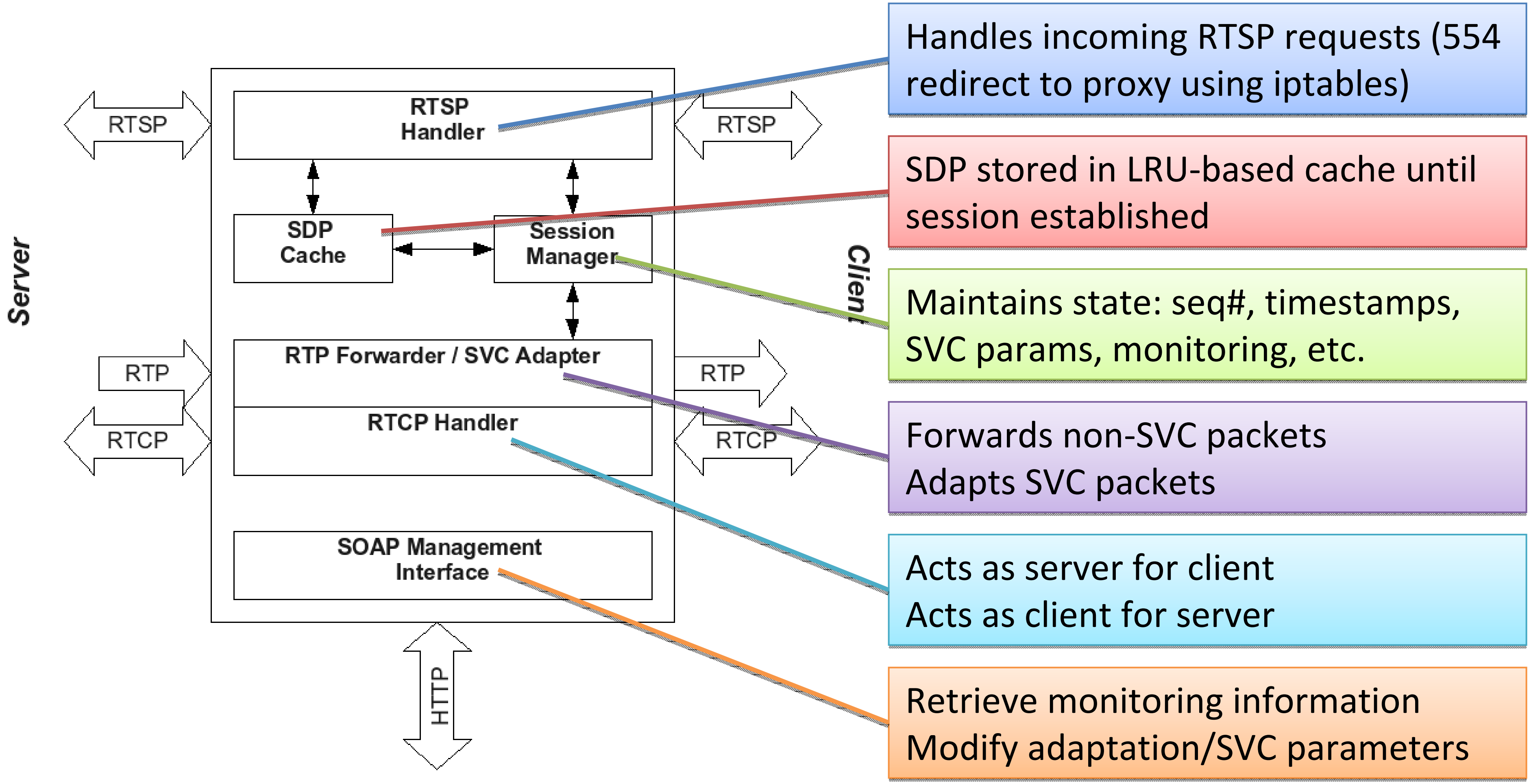
Benefits

- Session- and stream-/media-awareness
- Enables stateful inspection and processing of packets
- Allows adaptation on a per-session basis
- Consistent RTCP receiver and sender reports

Drawbacks

- Proxy is running as user-space process
- RTP packets have to be passed (copied) from the kernel-space to the user-space and vice versa
- Decreases theoretical throughput compared to kernel-internal solution (e.g. filtering on IP level)

Architecture



Performance Evaluations

- Hardware: Linksys WRT 54 GL
  - Broadcom System-on-Chip BCM5352EL
  - MIPS32 200 MHz CPU
  - 16 MB RAM
  - 4 MB Flash Memory
  - IEEE 802.11b/g WLAN
  - Fast Ethernet switch with 5 ports
  - price ~ 45 Euros (May 2008)

- Software: OpenWrt
  - Linux-based firmware for Broadcom-based WiFi routers
  - gcc-based SDK for OpenWrt available
  - Proxy implementation in ANSI C

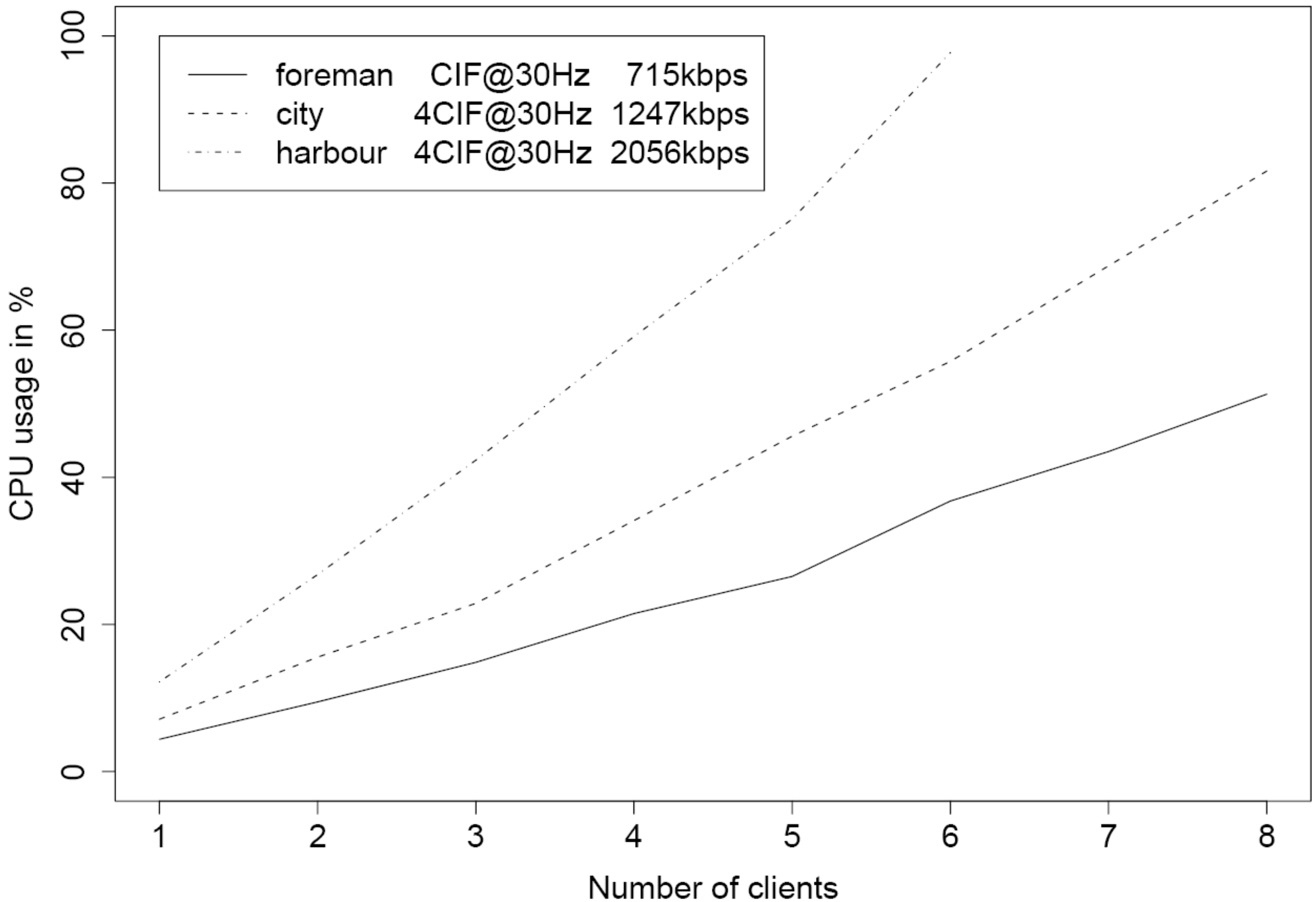
OpenWrt
Wireless Freedom

Performance Evaluations (cont'd)

- Evaluation of the implementation on the target platform
  - Server – proxy – client deployment
  - Investigation of worst-case scenario (no adaptation)
- Performance metrics
  - CPU usage for different number of streams
  - Delay introduced by the proxy on a complete access unit (frame)
- Three different SVC streams for evaluation
  - Foreman, CIF, 30 Hz, 715 kbps
  - City, 4CIF, 30 Hz, 1247 kbps
  - Harbour, 4CIF, 30 Hz, 2056 kbps

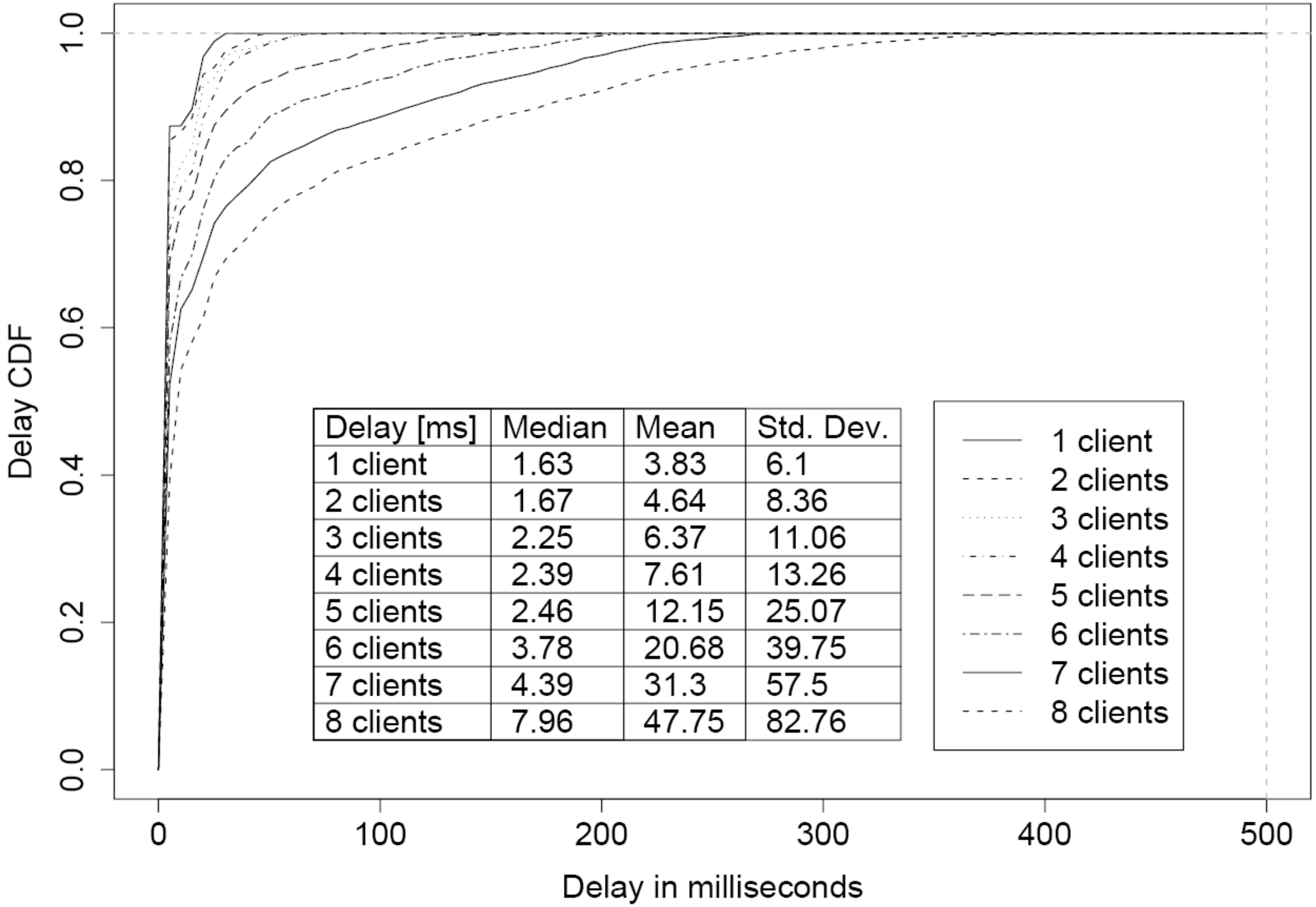
Performance Evaluations (cont'd)

CPU Usage



Performance Evaluations (cont'd)

CDF of delay for sequence *city (1245 kbps)*



Delay [ms]	Median	Mean	Std. Dev.
1 client	1.63	3.83	6.1
2 clients	1.67	4.64	8.36
3 clients	2.25	6.37	11.06
4 clients	2.39	7.61	13.26
5 clients	2.46	12.15	25.07
6 clients	3.78	20.68	39.75
7 clients	4.39	31.3	57.5
8 clients	7.96	47.75	82.76

Demo Video

Conclusions

- Proxy approach for in-network adaptation on a per-packet basis
  - Aware of sessions and individual streams (media-aware)
  - Stateful, not a simple packet dropper
- Applications
  - Adaptation according to device capabilities
  - Cross-layer adaptation
  - NAT traversal
- Performance sufficient for typical home deployments
  - 4 parallel streams with 30 percent CPU load and < 100 ms delay

→ SVC adaptation can be done on existing off-the-shelf network devices

References

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Thank you for your attention

... questions, comments, etc. are welcome …

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