Adaptive Channel Scanning for IEEE 802.16e

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10/24/06

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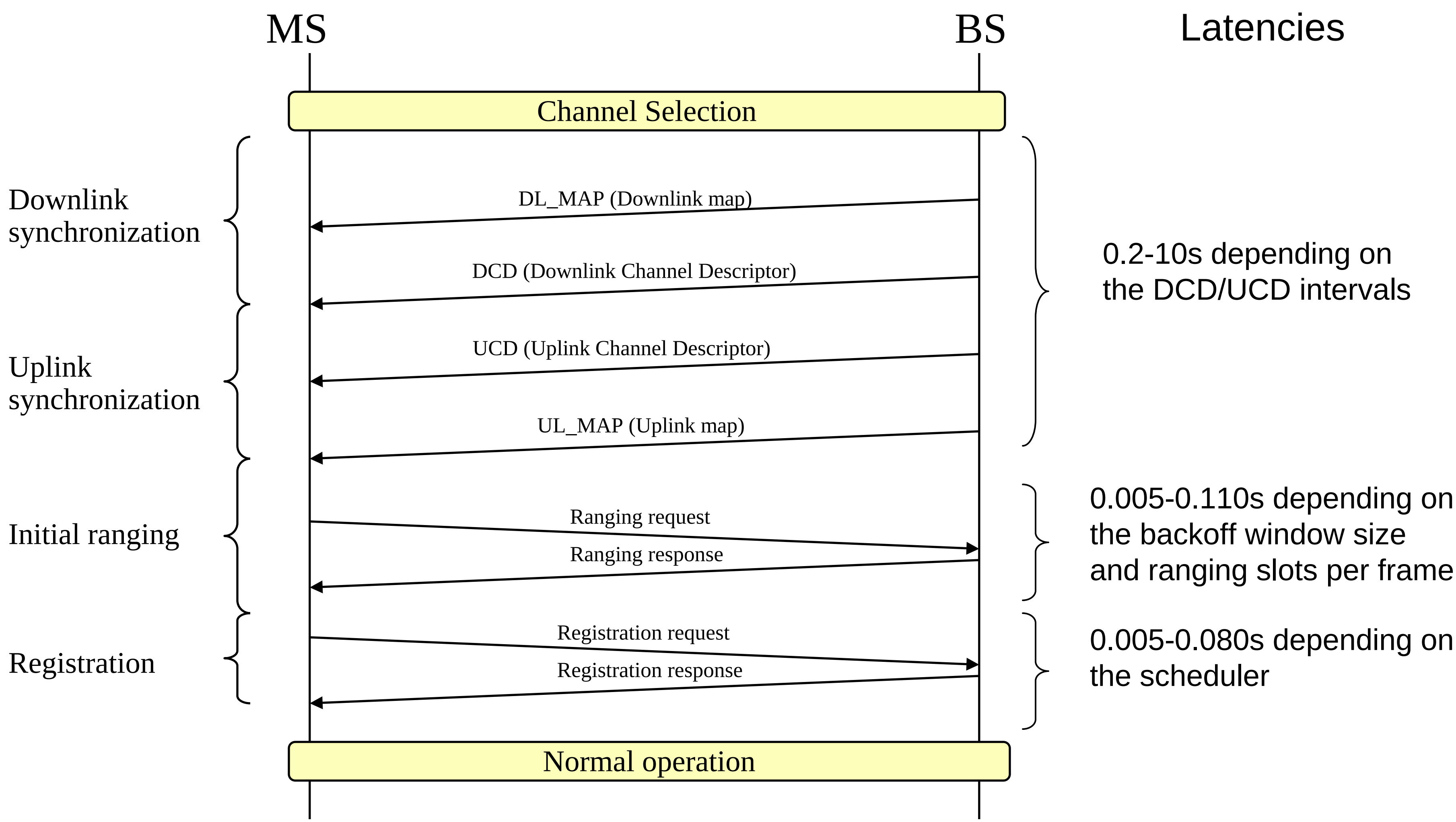
Motivation and Objectives

- Channel scanning is needed in order for a Mobile Station (MS) to change its Base Station (BS).
- The IEEE 802.16e specifications provide support for performing channel scanning while keeping the current connection. This is done by interleaving channel scanning and data transmission intervals.
- However, the standard does not specify how this is done.
- This paper proposes an algorithm for adaptive channel scanning that:
  - Reduces the overall channel scanning time
  - Support applications QoS requirements.

Main features of IEEE 802.16

- High data rate (up to 100Mbps)
- Large coverage area (up to 50 km LOS)
- Multiple physical layers for frequencies under 11Ghz or between 10GHz and 60GHz
- Extension for mobility supporting fast handovers (IEEE 802.16e)

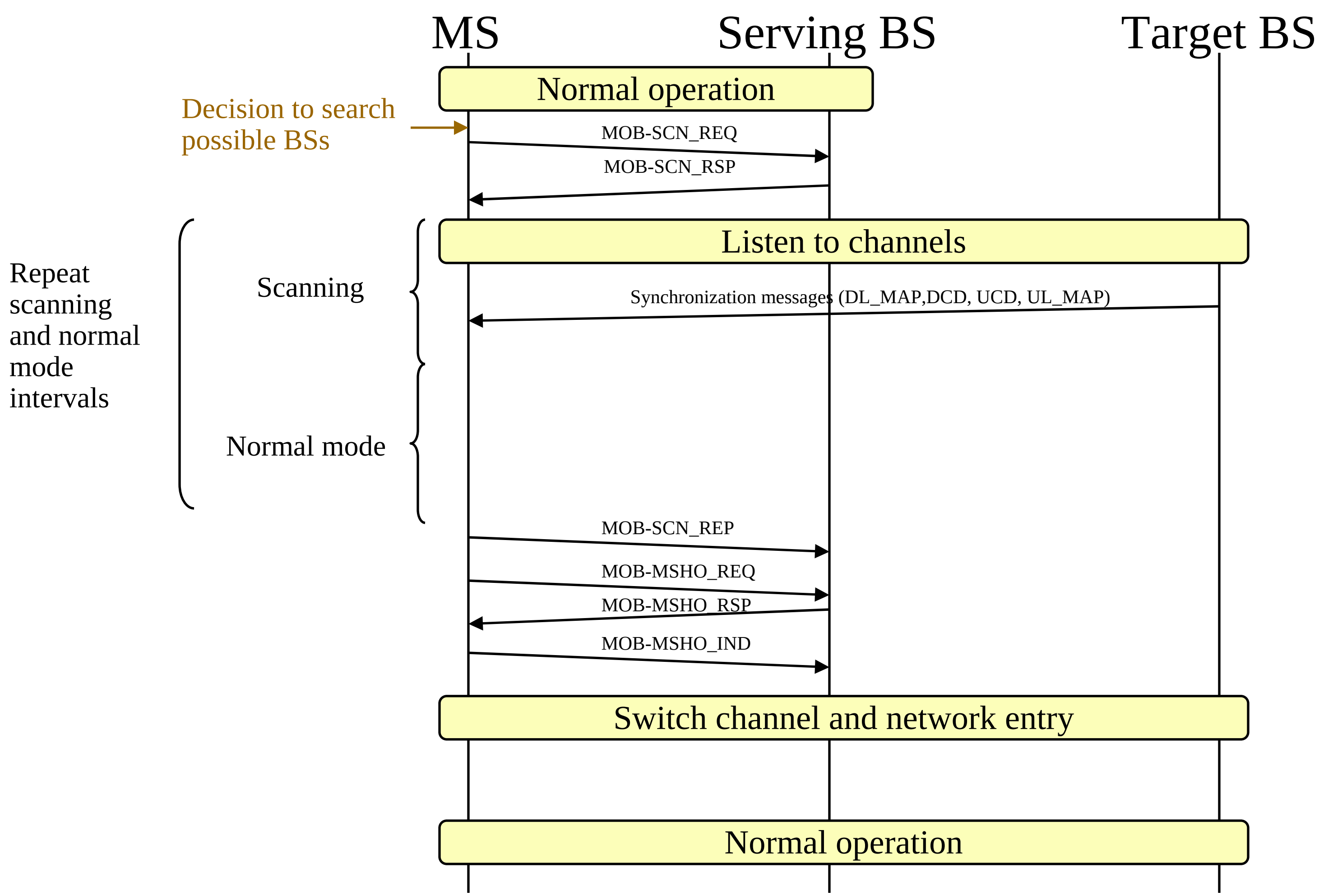
Network Entry in IEEE 802.16



Channel Scanning in IEEE 802.16e

- Exchange of information with neighboring BSs such as DCD and UCD messages
- Broadcast of neighboring information (DCD and UCD messages) to connected MSs
- Synchronization between scanning MS and serving BS to reduce packet loss
  - Messages exchange
  - Negotiation of scanning time

Channel Scanning in IEEE 802.16e



Scanning modes in IEEE 802.16e

There are four scanning modes defined:

- In scan without association, the MS attempts to identify and synchronize with one or more BSs. It also estimates the signal quality.
- In association level 0, the target BS has no information about the scanning MS and only provides contention-based ranging allocations. After sending a ranging request, the MS waits for a response from the BS with a default timeout value of 50ms.
- In association level 1, the serving BS negotiates with the target BSs a time at which the MS will find a dedicated ranging region. After sending a ranging request, the MS waits for a response from the BS with a default timeout value of 50ms.
- In association level 2, also called network assisted association reporting, the procedure is similar to level 1 except that the MS does not wait for a response from the target BS. The ranging response is sent by the target BS to the serving BS over the backbone, which then forwards it to the MS.

Proposed solution

Objectives of the Adaptive Channel Scanning (ACS) algorithm: minimize the disruptive effects of scanning on the application traffic by using the QoS traffic requirements.

Assumptions:

- Neighboring BSs exchange information over the backbone
- The messages are extended to fit the information required by the algorithm

Stage 1: estimate the time needed by a MS to scan the possible neighboring stations

Stage 2: compute the interleaving of channel scanning and data transmission intervals

ACS stage 1: scanning time estimation

The scanning time consists of two elements:

- Synchronization latency: DCD and UCD messages are provided by the serving BS. The MS only waits for DL_MAP and UL_MAP messages, generally located in each frame.
- Association latency: depends on the association level provided by the neighbor BS.

Association level	**Association latency**	**Attributes**
Level 0	$\left\lfloor \frac{2^{B_{\exp}}-1}{n_{cs}} \right\rfloor \times t_f + t_{out}$	$B_{\exp}$ is the backoff exponent t_f the frame duration t_{out} the timeout value for receiving a ranging response (default: 50ms)
Level 1	t_{out}	t_{out} the timeout value for receiving a ranging response (default: 50ms)
Level 2	0	

ACS stage 2: Interleaving of channel scanning and data transmission intervals

- The algorithm computes the following information:
  - Channel scanning duration
  - Duration between scanning iterations
  - Number of scanning iterations
- The information used is:
  - Quality of Service of the applications
  - Available bandwidth
  - Number of concurrent scanning stations

ACS algorithm

Initialization

Scanning interval = min of all jitters and latencies
Interleaved duration = (Number of scanning station-1) * scanning interval
Number of iterations = scanning time of stage 1 / scanning interval
For each station,
  Buffered data = scanning interval * data rate
  Available bandwidth during scanning = total available bandwidth + data rate of MS

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Check if scattering of stations is enough

For each station, we check if the bandwidth available during the scanning of the other stations is enough. If not, increase the interleaved duration with a maximum of 255 * frame duration

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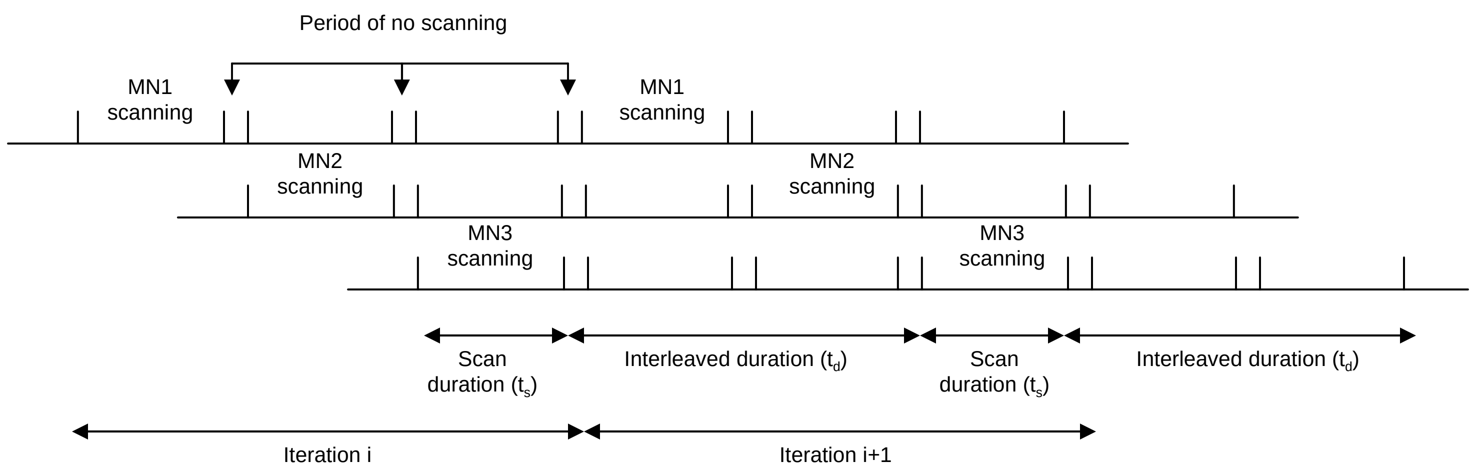
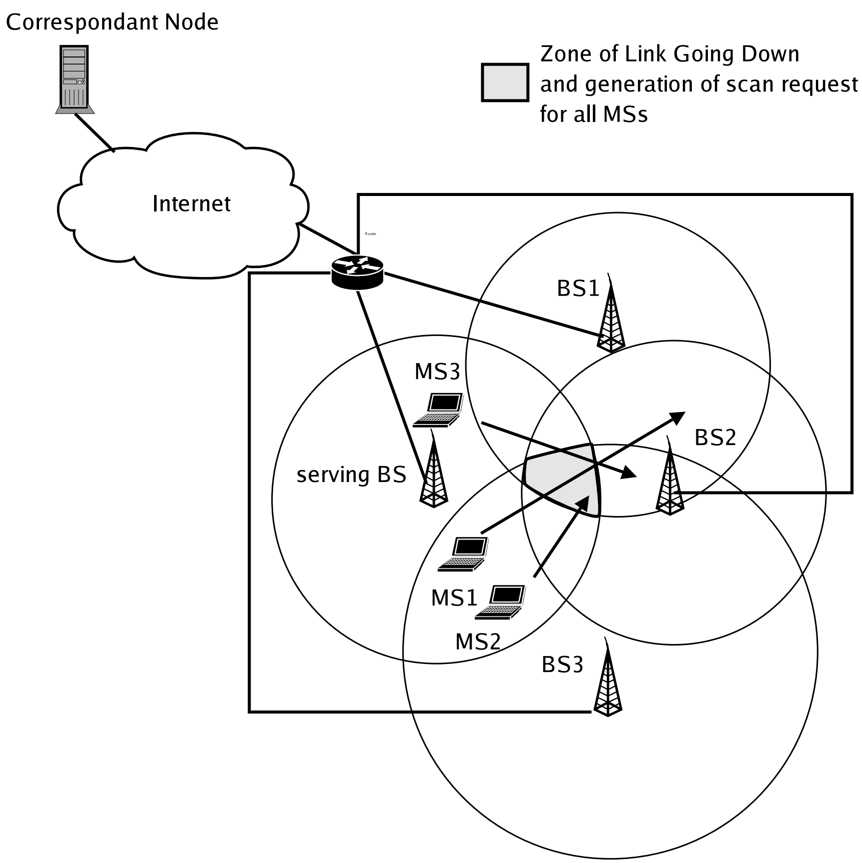
Assign starting time for each of the concurrent scanning station



Evaluation results: simulation scenario

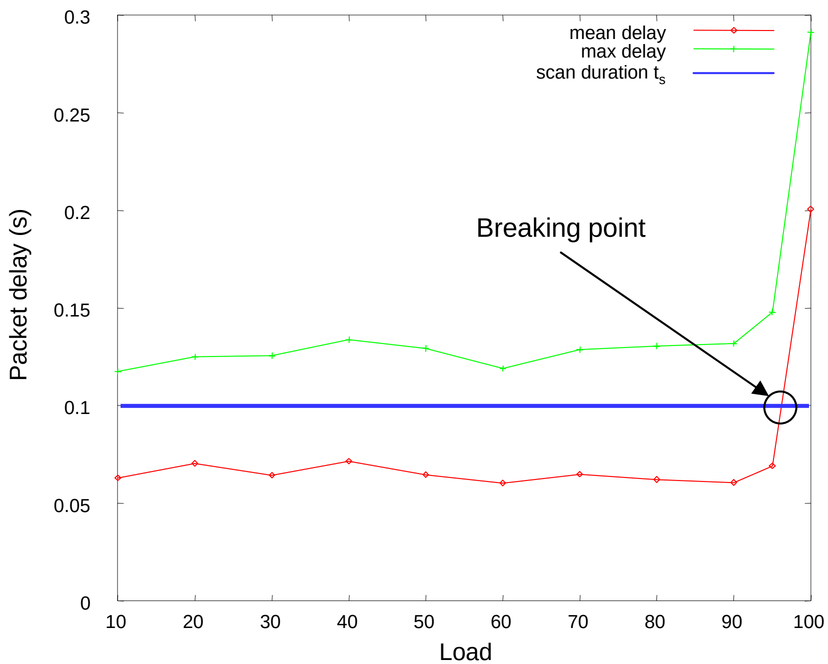


Base Station		l_s (ms)	l_a (ms)	t_{st} (ms)
Parameter	Value			
BS1		8	110	118
Association level	0			
B_{exp}	4			
N_{cs} (slot/frame)	1			
T_f (ms)	4			
BS2		8	50	58
Association level	1			
T_f (ms)	4			
BS3		16	306	314
Association level	0			
B_{exp}	6			
N_{cs} (slot/frame)	2			
T_f (ms)	8			
Total time required by MS to scan BSs (ms)		498		

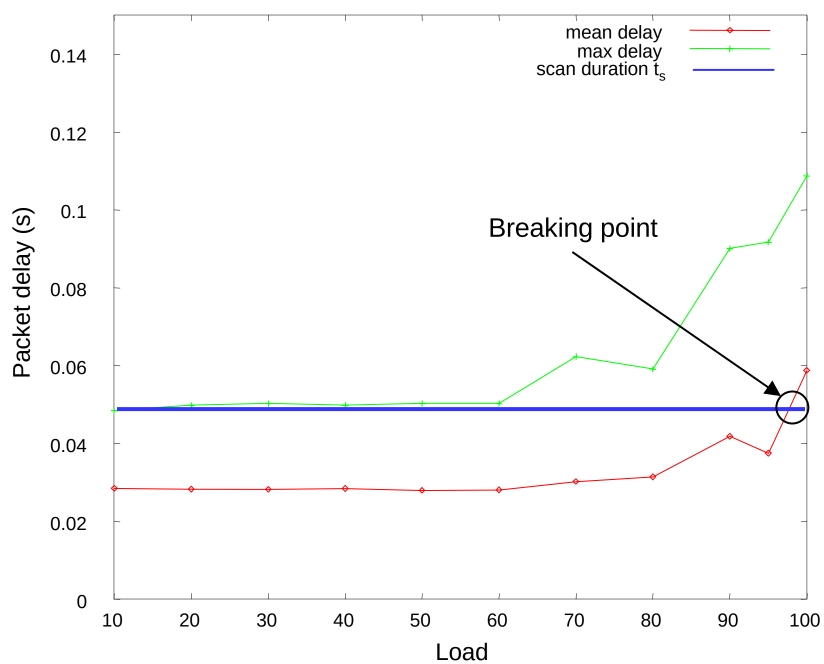
QoS Parameters	Requirements
Video (MS1 and MS3)	
Data rate (bytes/s)	49600
Jitter (ms)	100
Delay (ms)	200
Audio (MS2)	
Data rate (bytes/s)	8000
Jitter (ms)	50
Delay (ms)	75

Simulation: Packet delay measurements with a single MS

MS supporting video traffic



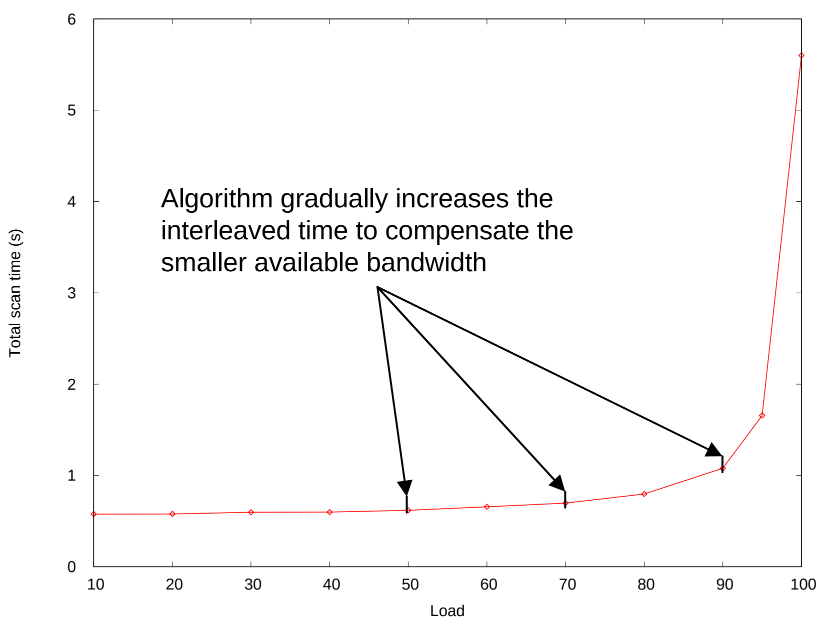
MS supporting audio traffic



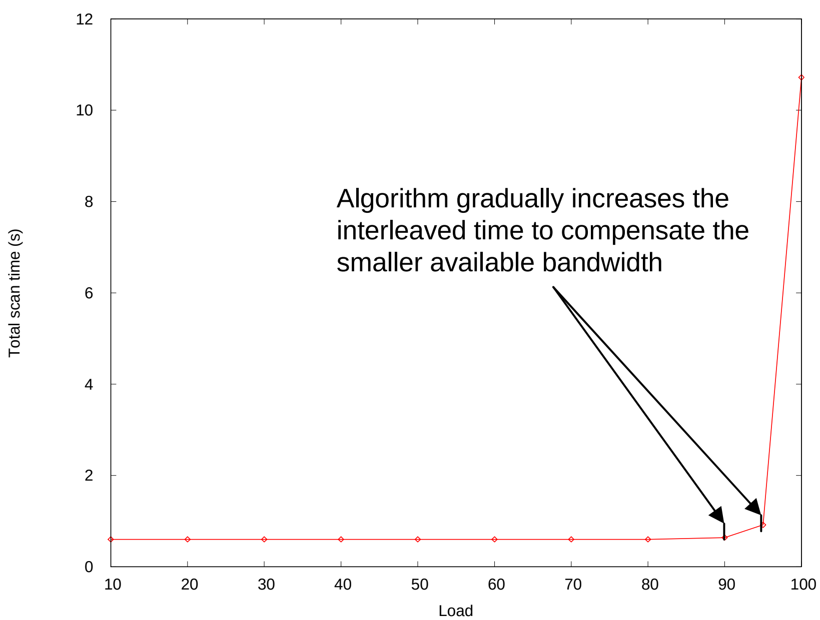
- As the load increases, there is less bandwidth available to flush the buffered data therefore the delay increases.
- For load over 95% for video and 98% for audio, not all buffered packets are sent during the interleaved time, which causes packet delay to exceed requirements.

Simulation: Total scanning time with a single MS

MS supporting video traffic

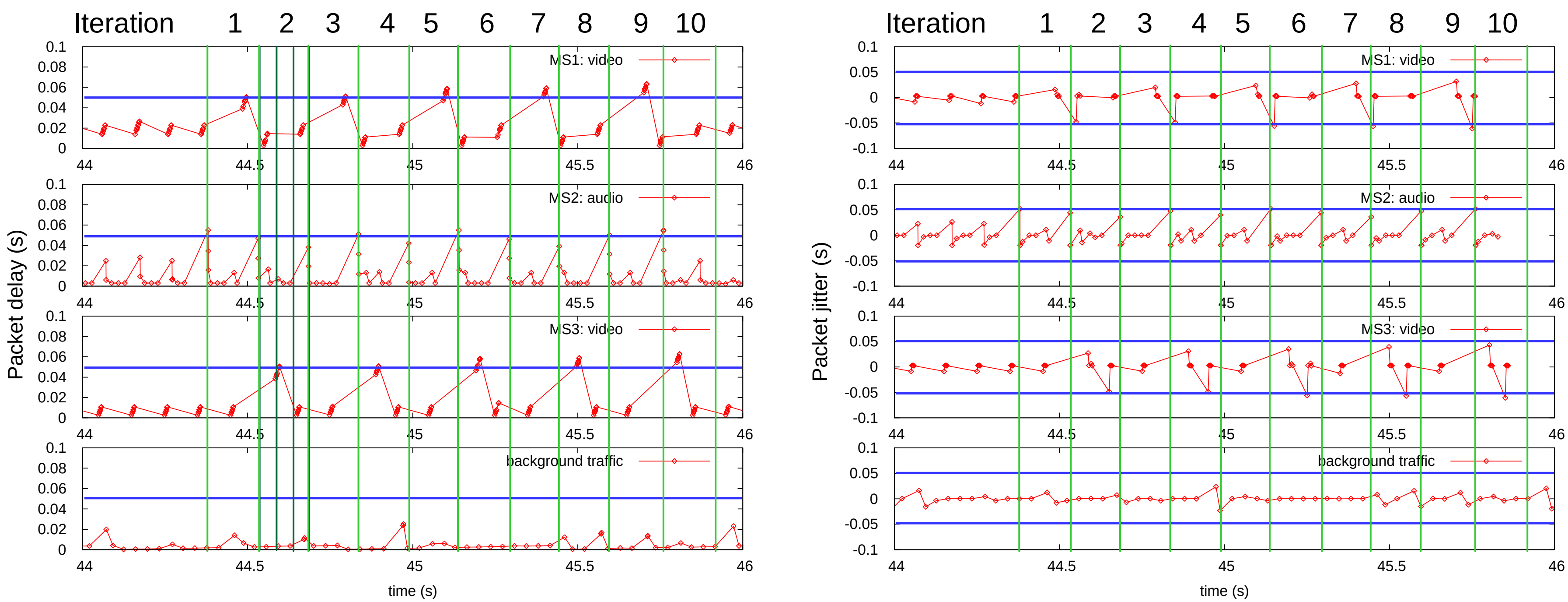


MS supporting audio traffic



- The maximum time to do all the scanning is $\left\lceil \frac{Scantime}{t_s} \right\rceil \times (255 \times t_f + t_s)$ with scantime=498ms, t_f=4ms
- For video: t_s=100ms. Maximum time to execute scanning is 5.6s
- For audio: t_s=50ms. Maximum time to execute scanning is 10.7s

Simulation: Packet delay measurements with three MSs



- Packet delay and jitter are kept within the required bounds.
- We can identify each iteration and the scattering of the scanning stations
- Peak values occur when the MS sends the first packet after scanning.
- Background traffic is minimally impacted

Conclusion

- The ACS algorithm uses configuration information shared by the BSs to estimate the scanning time required by a MS.
- It then uses the application's QoS to interleave period of normal data transmission and scanning duration
- Simulation results show that by using the algorithm, it is possible to minimize the impact of channel scanning on the traffic.
- The algorithm needs:
  - Accurate measurements of available bandwidth
  - Communication between BSs
- Future work will investigate
  - Efficiency of the ACS algorithm in detecting neighboring BSs
  - The scheduling of rendez-vous within the allocated scan duration

For more information

Information on the Seamless and Secure Mobility project is available online at http://www.antd.nist.gov/seamlessandsecure.shtml

The IEEE 802.16 model for NS-2 is available upon request to sswm-dev@antd.nist.gov