

Fachhochschule Köln
Cologne University of Applied Sciences



Evaluation of IP Radio Streaming Characteristics in a Mobile, Automotive Environment

Tobias Wallerius, Visteon Innovation & Technology GmbH
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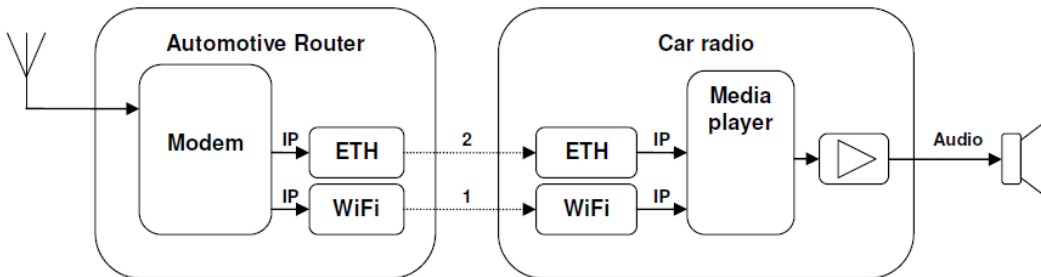
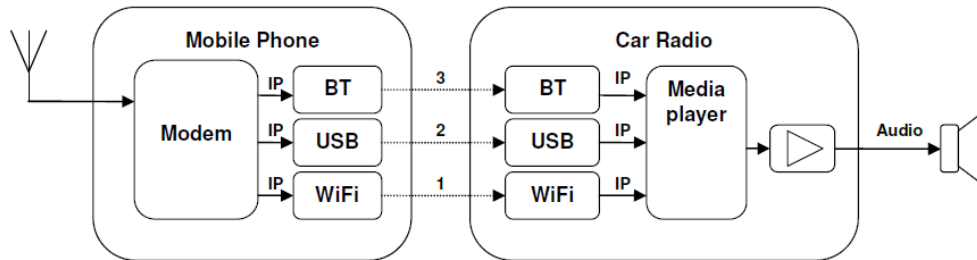
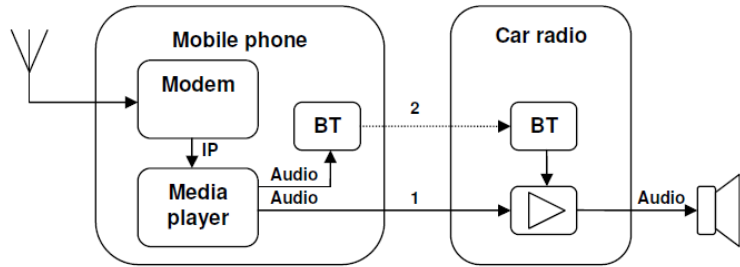
Introduction

- Internet radio reception possible at home today
- Next step: Reception in vehicles
- This study focuses on:
 - Defining a measurement environment and parameters
 - Evaluation on potential of today's mobile network technology for Internet radio
 - Comparing the reception performance of an automotive router (with external vehicle antenna) vs. a smartphone
 - Comparing the performance of 128 kbps vs. 64 kbps streams

Car Receiver Performance Measurements



Three Typical Scenarios for In-Car Internet Radio



Pro

Cheap

Optimized media player in radio

Little driver distraction

Expensive

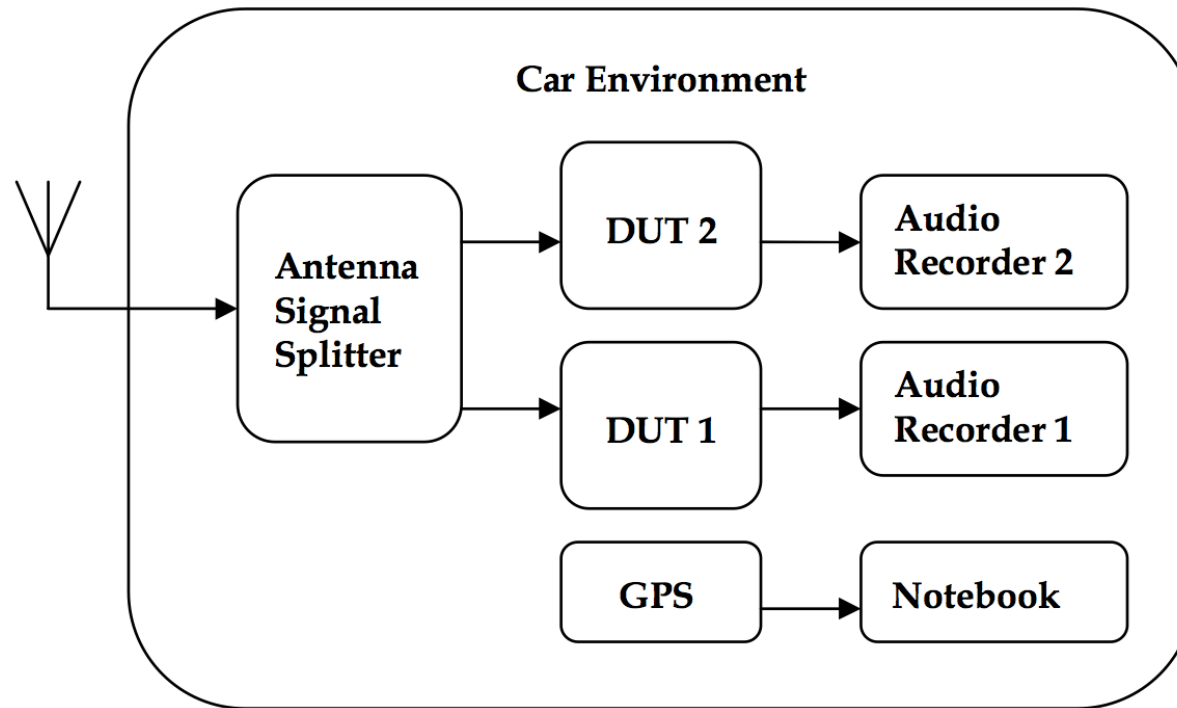
Contra

Media player not robust, losing connection

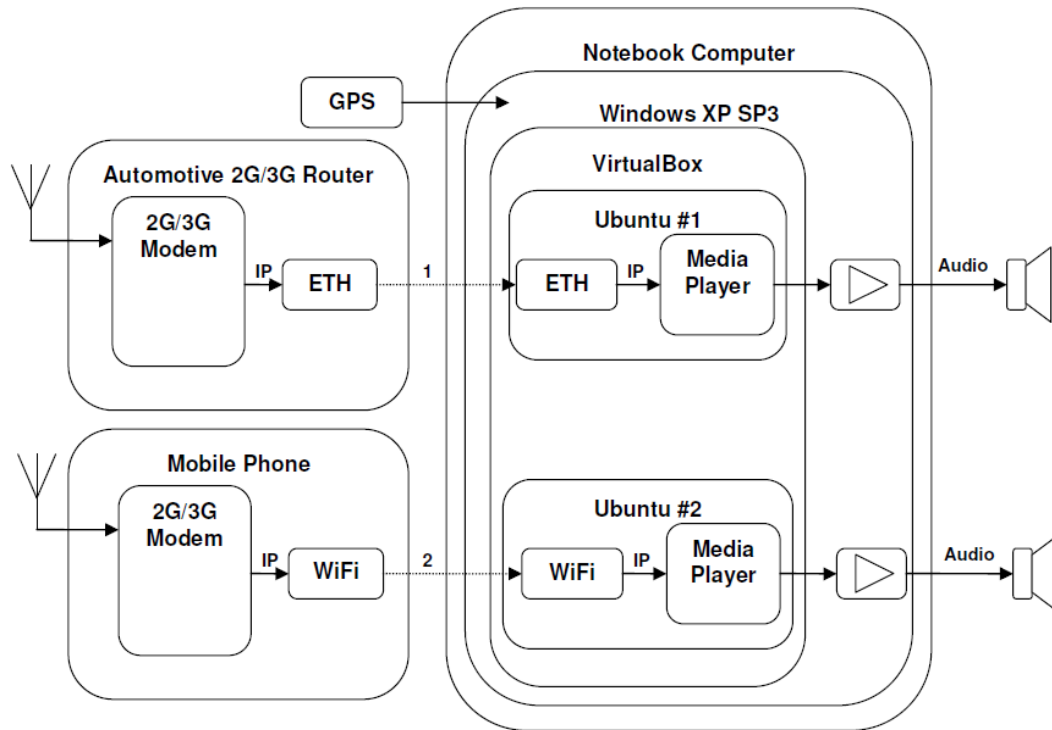
Driver distraction

Non optimal phone placement in the car

Assumed to provide best reception performance



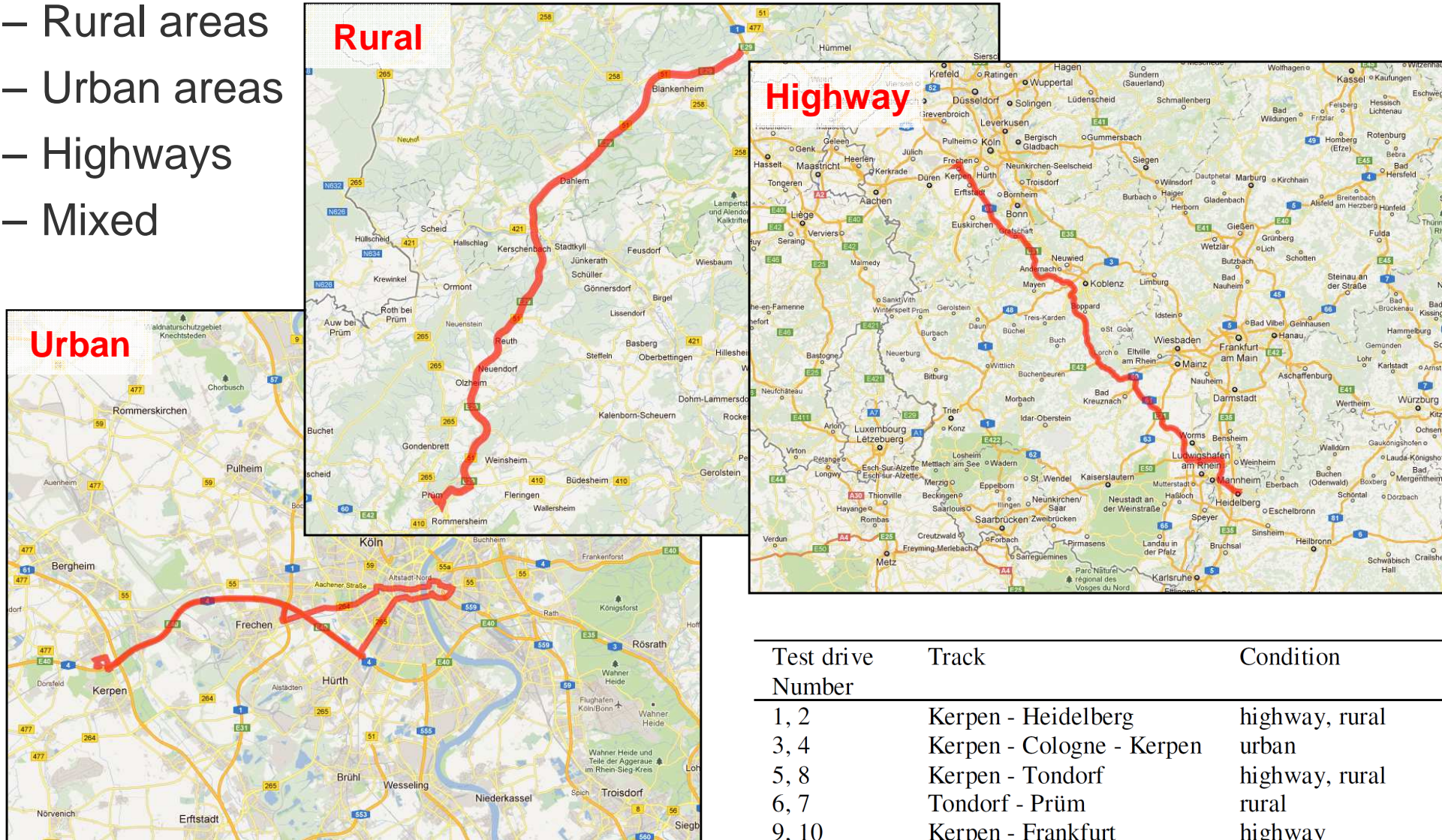
- User's quality experience measured by comparing receiver audio output
- Key parameter is audio availability on test route
- Audio availability >95% of the time is considered as good



- Virtualization
 - Oracle (Sun) VirtualBox, Ubuntu as OS
- Audio recording
 - arecord
- Network traffic capturing
 - tshark
- Router status logging
 - Router engineering firmware and log script
- GPS logging
 - USB receiver

Selection of Test Routes

- Test routes selected to ensure diversity
 - Rural areas
 - Urban areas
 - Highways
 - Mixed

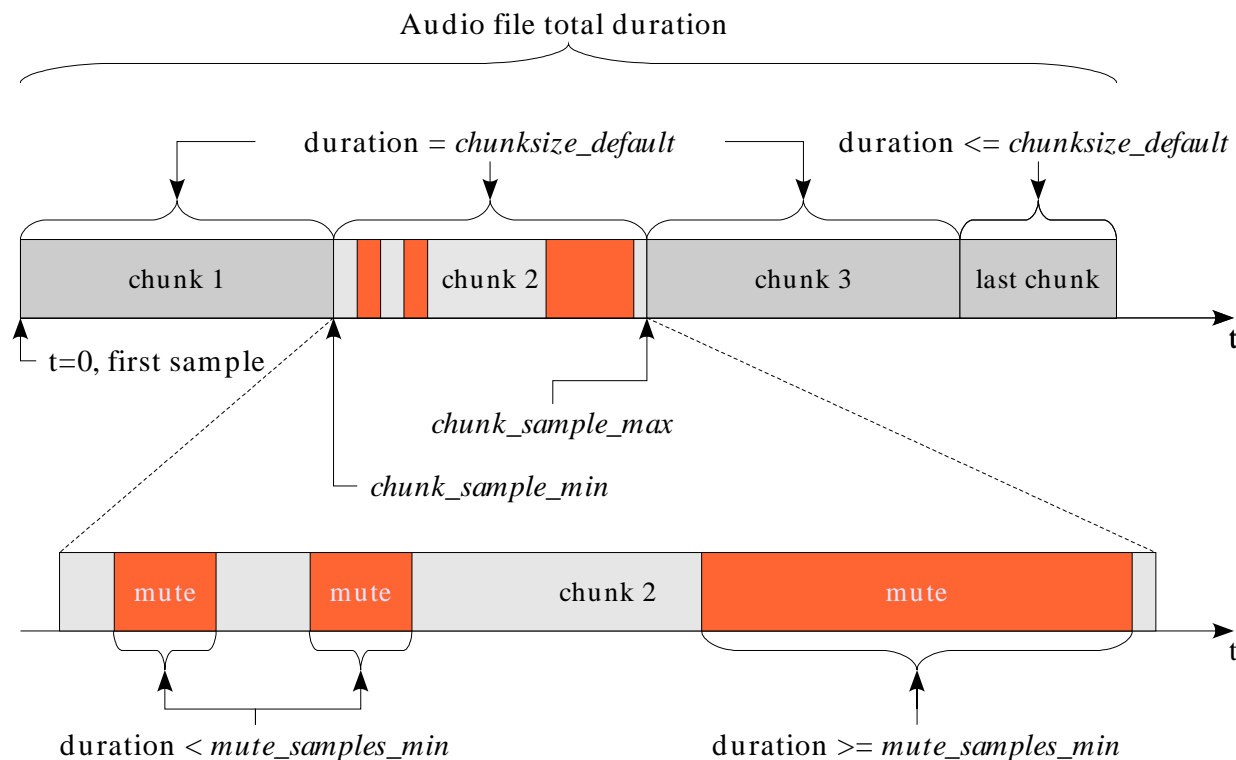


Test drive Number	Track	Condition
1, 2	Kerpen - Heidelberg	highway, rural
3, 4	Kerpen - Cologne - Kerpen	urban
5, 8	Kerpen - Tondorf	highway, rural
6, 7	Tondorf - Prüm	rural
9, 10	Kerpen - Frankfurt	highway

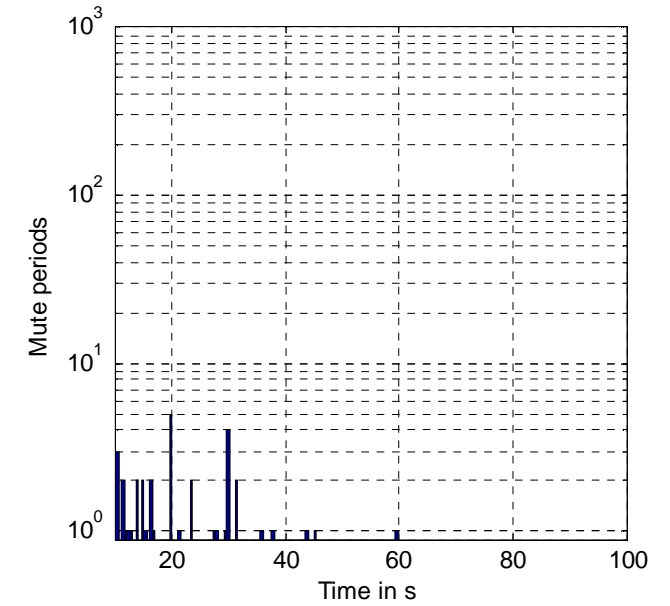
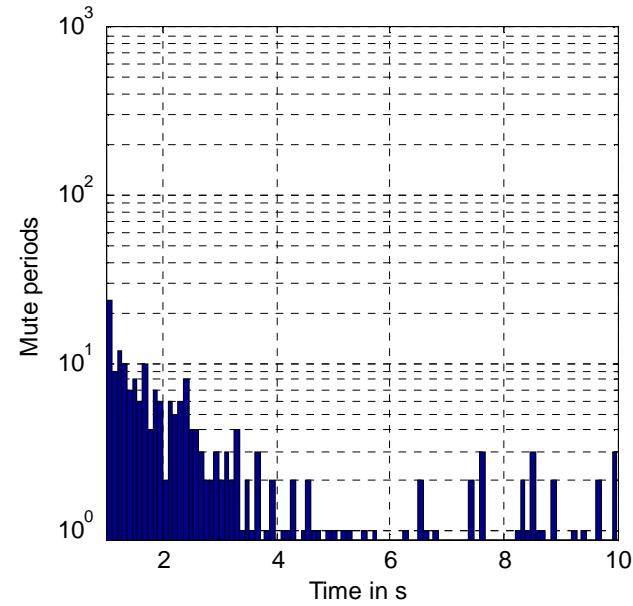
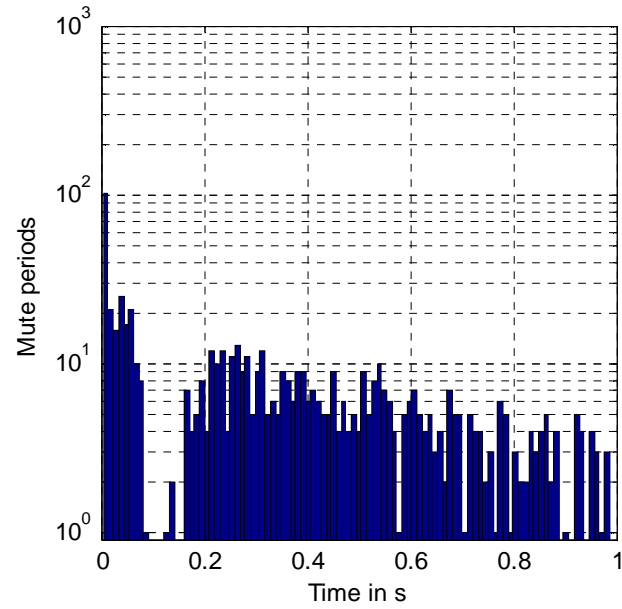
Data Analysis



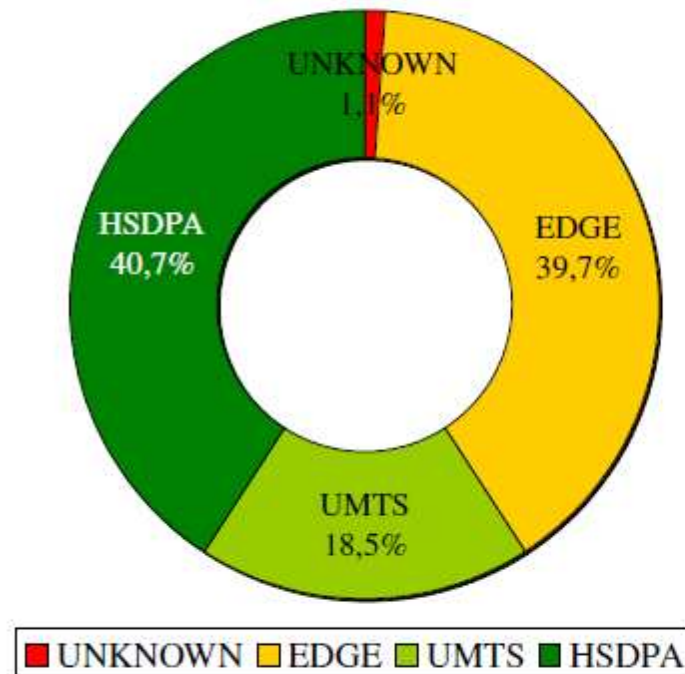
- Receiver audio output has been recorded during test drives
- Audio files (.wav) have been analyzed with MATLAB to get
 - Total audio muting time
 - Length distribution of mutings
- Audio has been processed in chunks to overcome MATLAB's memory limitations



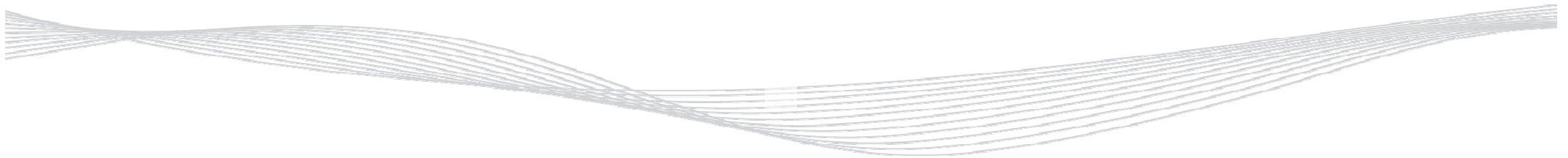
Mute Duration Histograms



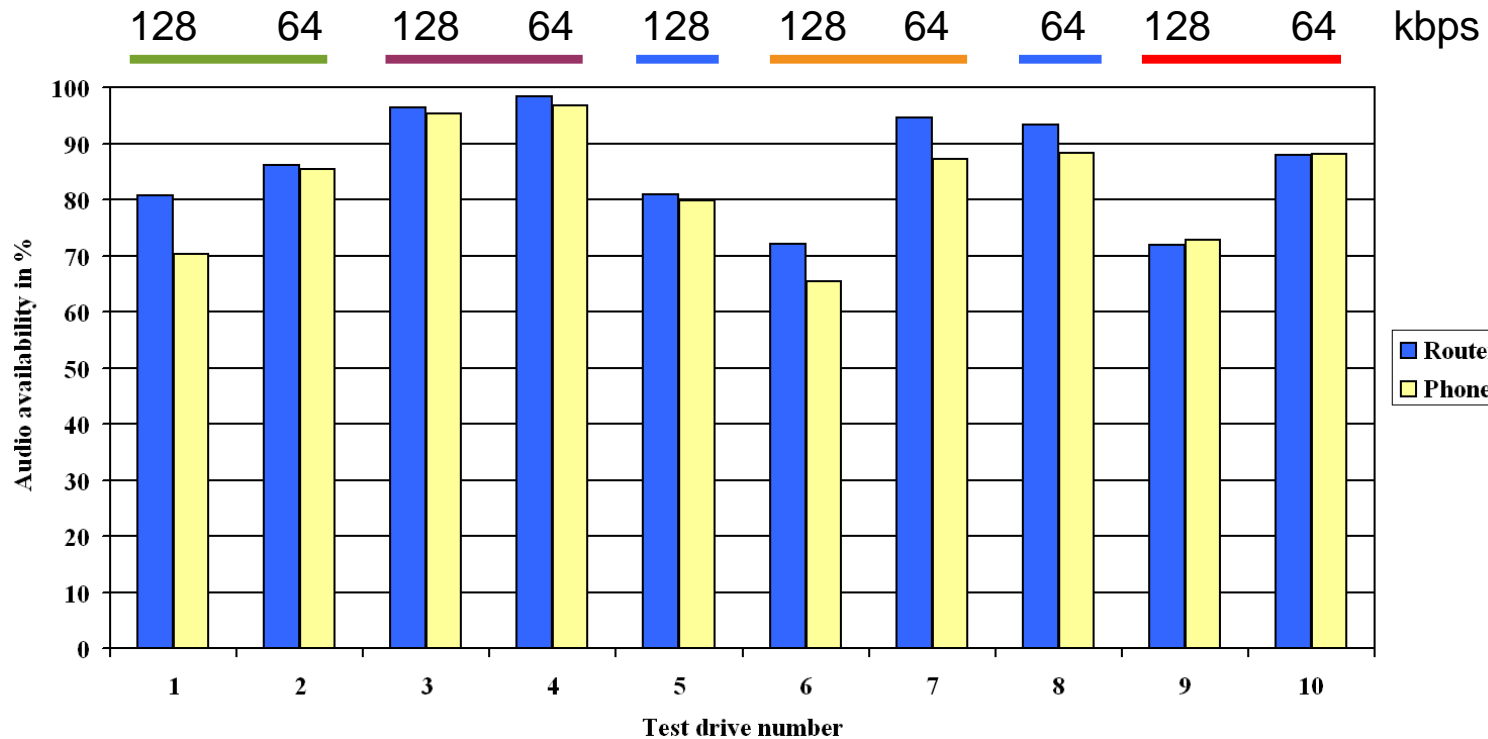
- Network availability and speed has been constantly monitored and recorded during test drives
- Router log files have been examined
- Enabled analysis of network speed distribution on test routes



Results



Audio Availability



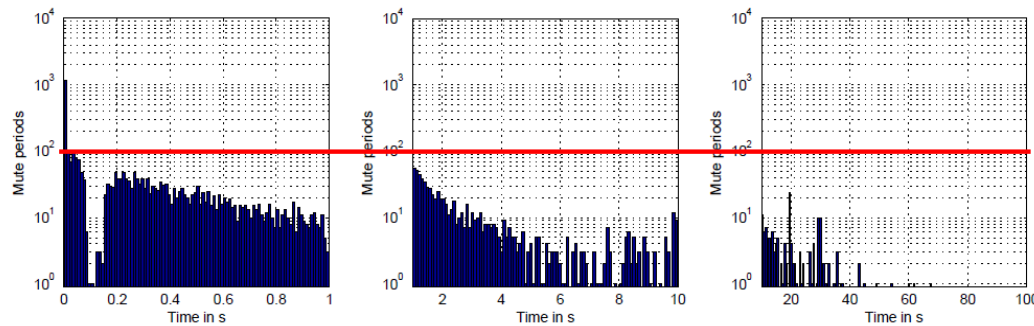
- On 8 out of 10 test drives, router performs better than smartphone
- Audio availability is always better when using 64 kbps streams
- Difference between 128 and 64 kbps is not significant in urban areas

Test drive Number	Track	Condition
■ 1, 2	Kerpen - Heidelberg	highway, rural
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■ 5, 8	Kerpen - Tondorf	highway, rural
■ 6, 7	Tondorf - Prüm	rural
■ 9, 10	Kerpen - Frankfurt	highway

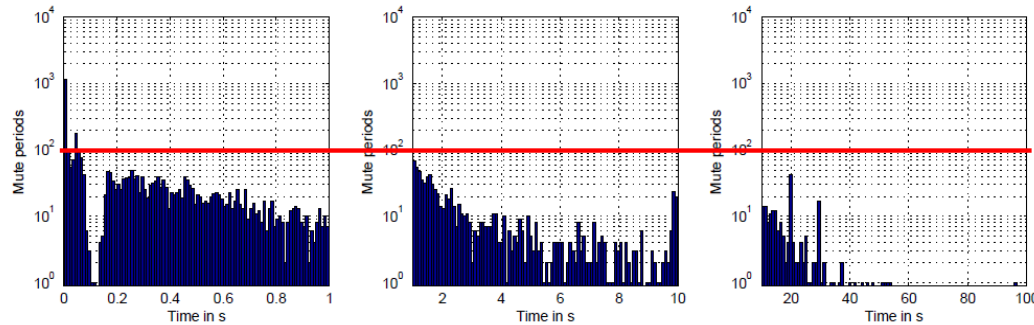
Automotive Router vs. Mobile Phone



- Automotive router with roof antenna does not perform significantly better than the smartphone inside the car
- Assumed reason: Good mobile networks and more up-to-date modem technology in mobile phone



Total Muting Time Distribution: Router



Total Muting Time Distribution: Smartphone

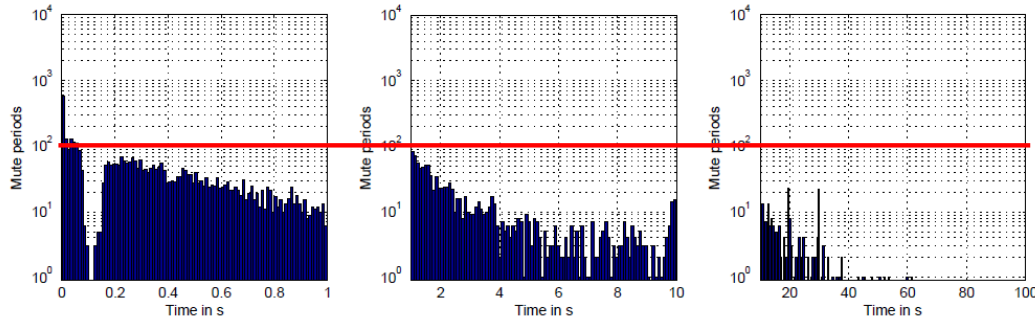
	Router	Smartphone
Overall audio availability (%)	86.2	82.9

- In rural terrain with bad network coverage the router performs up to 7% better

128 kbps vs. 64 kbps Streams

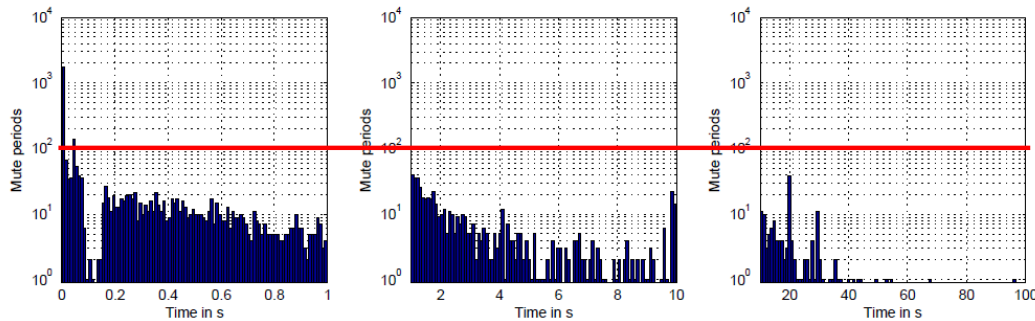


- Reception can be improved with lower bit rate streams (64 kbps) vs. higher bit rate streams (128 kbps)
- Amount of muting significantly lower



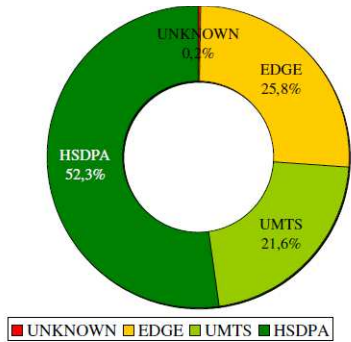
	128 kbps	64 kbps
Overall audio availability (%)	78.6	90.6

Total Muting Time Distribution: 128 kbps Streams

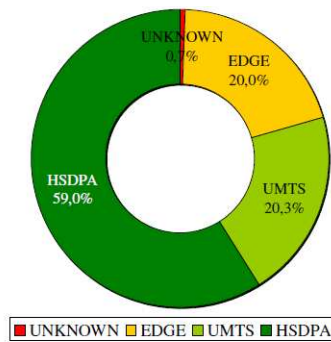


Total Muting Time Distribution: 64 kbps Streams

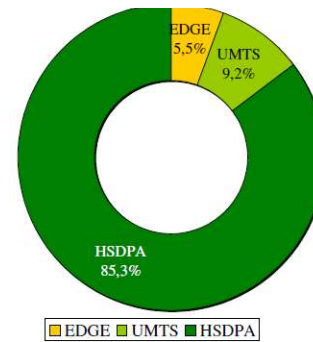
- Overall, audio availability is ~12% better when using 64 kbps streams



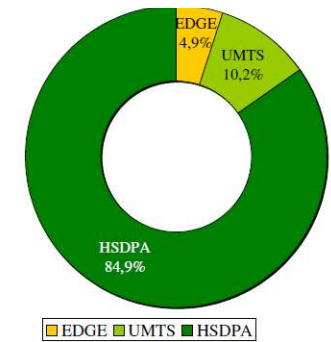
Test Drive 1 and 2 (highway, rural)



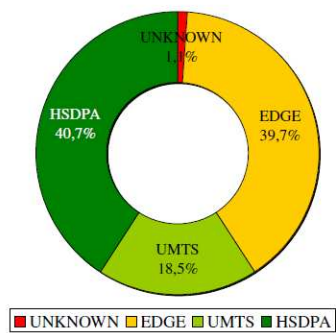
Test Drive 3 and 4 (urban)



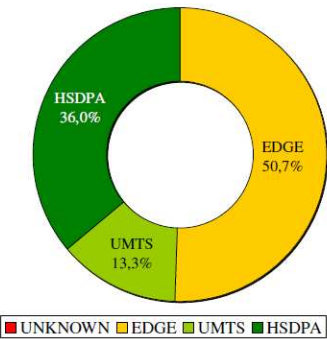
Test Drive 5 and 8 (highway, rural)



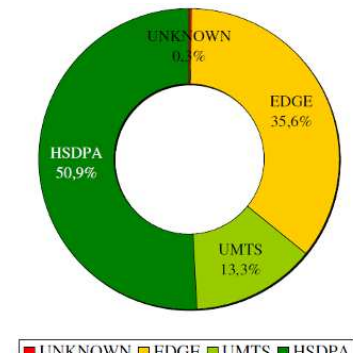
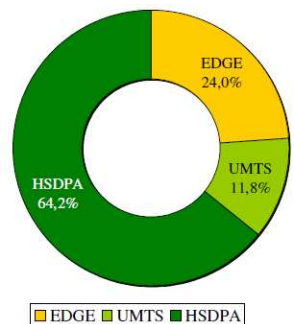
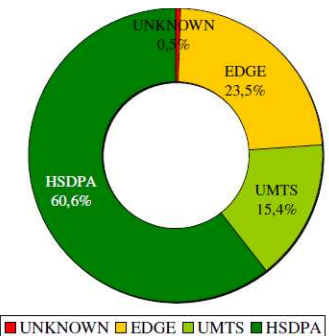
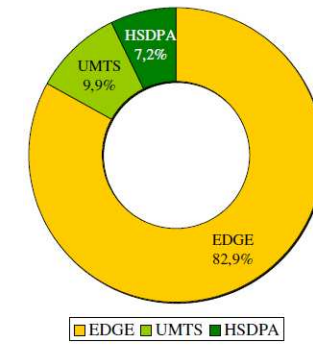
Test Drive 6 and 7 (rural)



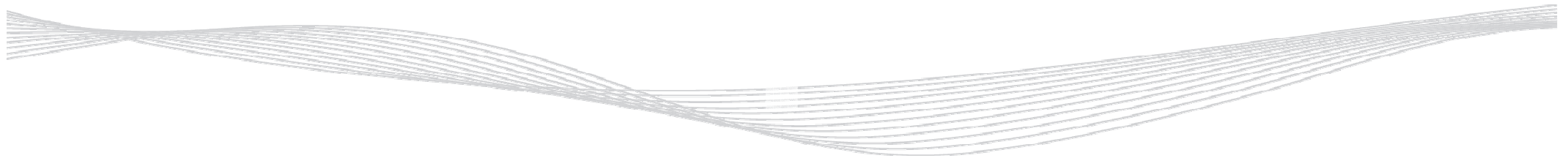
Test Drive 9 and 10 (highway, rural)



Overall



Conclusion



Results

- Reception in the vehicle is feasible but good quality only achievable in urban areas with good network coverage
- Audio availability around 95% in urban and only 70% in rural areas
- Using an automotive router with external antenna did not significantly increase audio availability vs. using a smartphone
- Stream bit rate has biggest influence on audio availability
- Currently used protocols are not optimized for mobile reception and improvement is possible

Forecast

- Radio technology, protocols, and receiver design will be optimized
- Internet enriched services in the car will be a standard feature in the future



www.visteon.com

