Comparing Time-Triggered Ethernet with FlexRay:

An Evaluation of Competing Approaches to Real-time for In-Vehicle Networks

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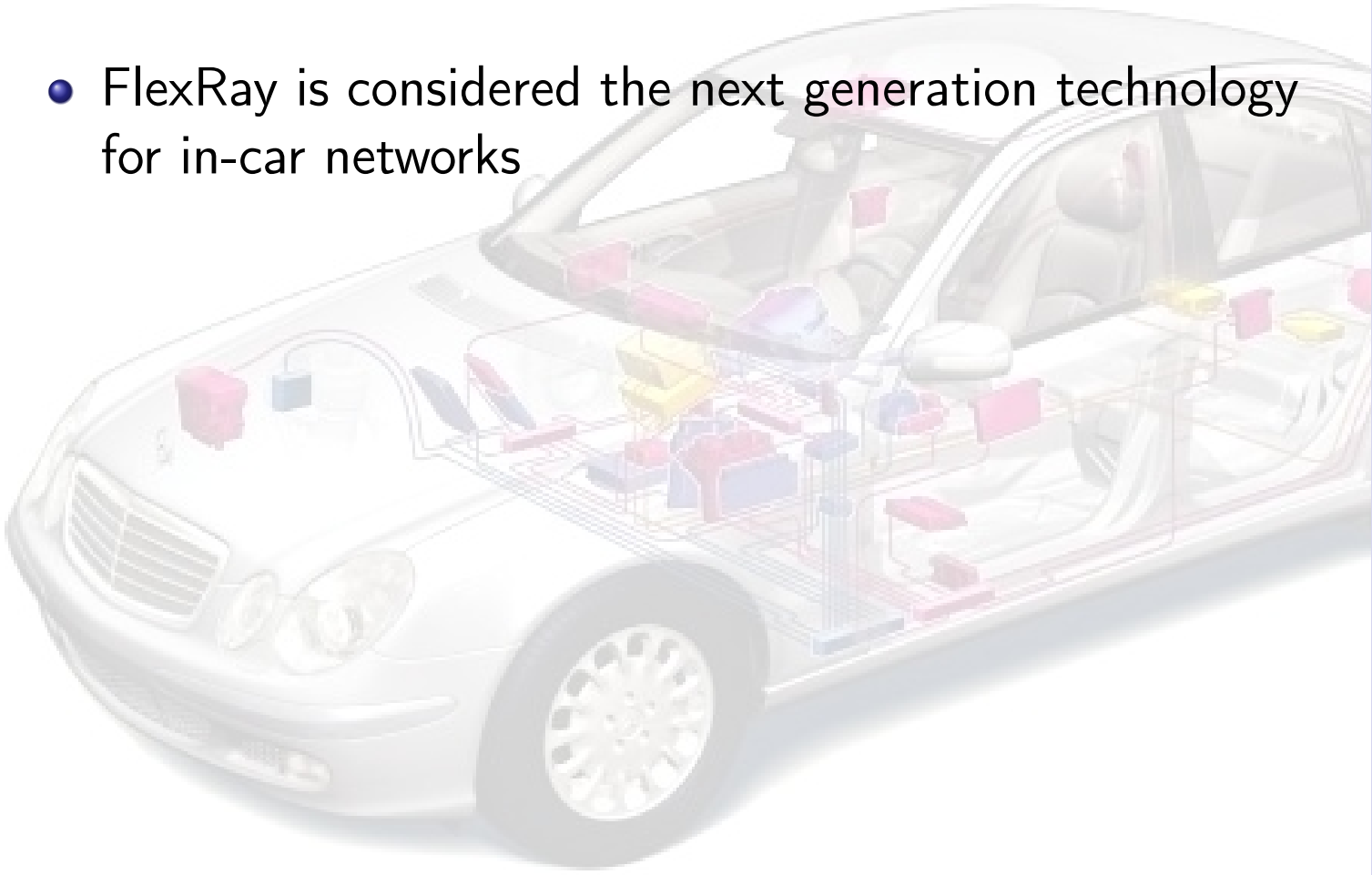
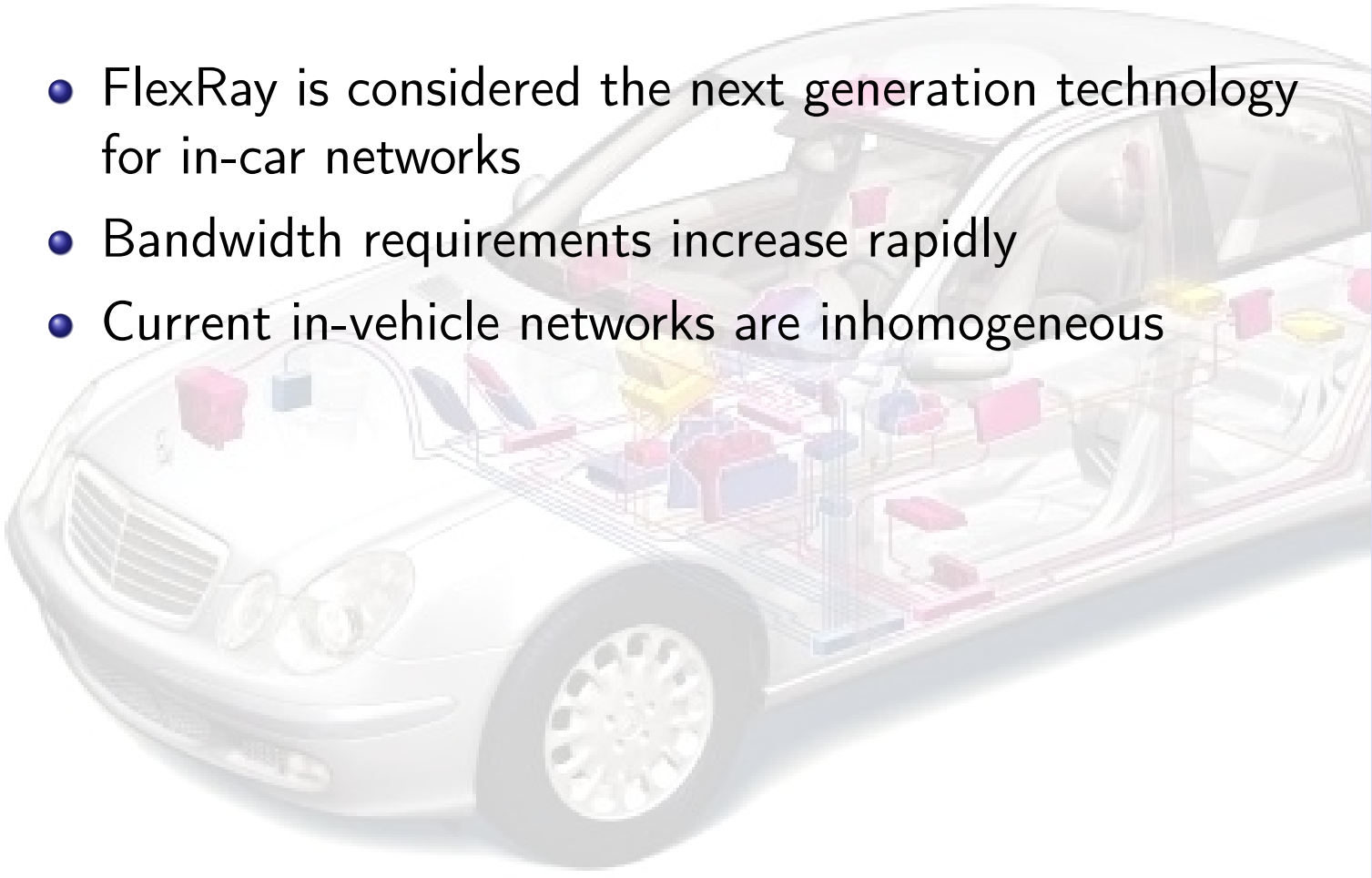
- FlexRay is considered the next generation technology for in-car networks





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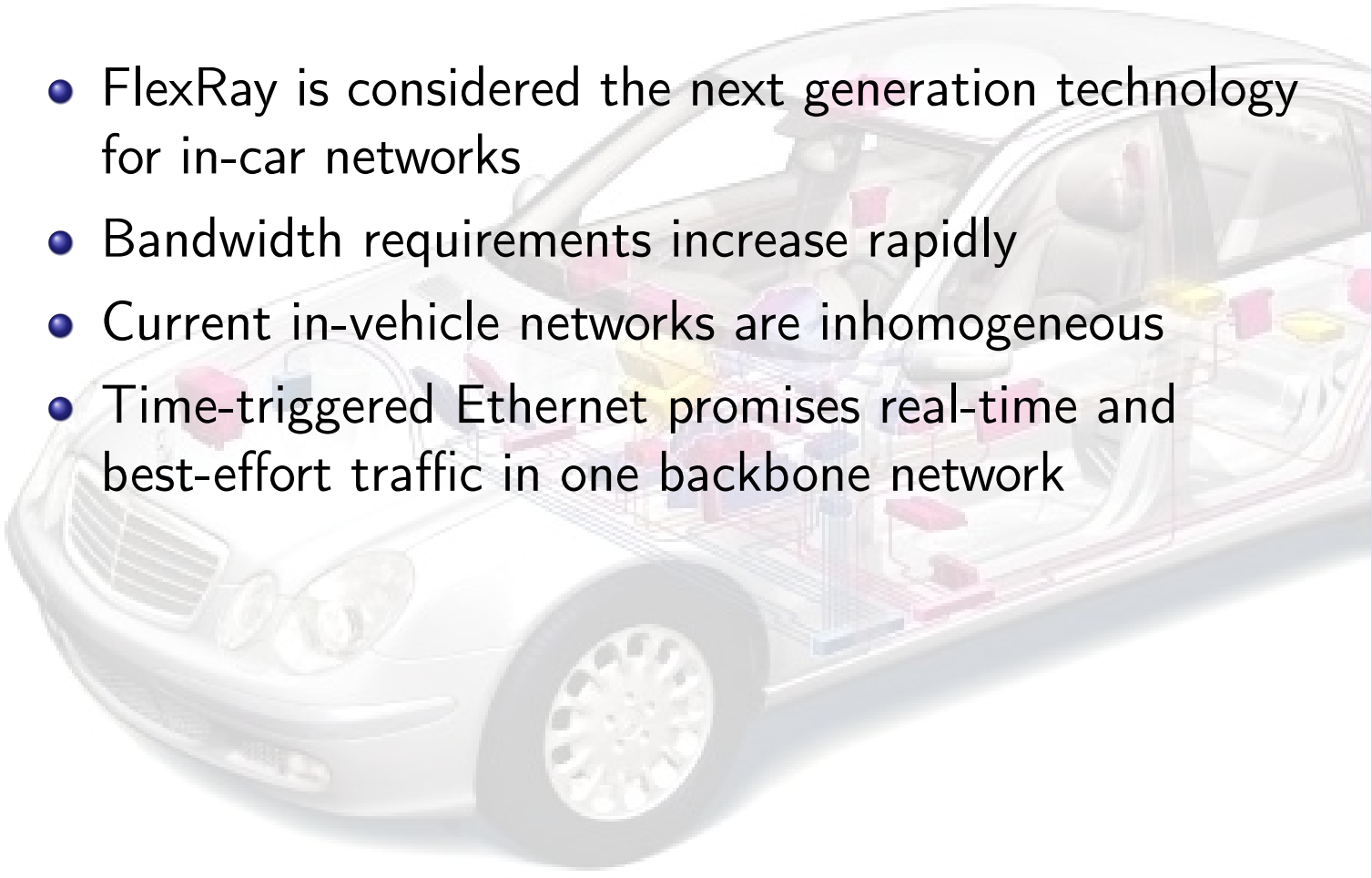
- Bandwidth requirements increase rapidly
- Current in-vehicle networks are inhomogeneous



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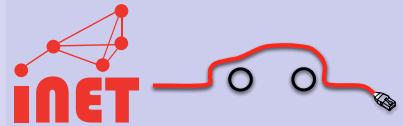
- Time-triggered Ethernet promises real-time and best-effort traffic in one backbone network



- FlexRay is considered the next generation technology for in-car networks
- Bandwidth requirements increase rapidly
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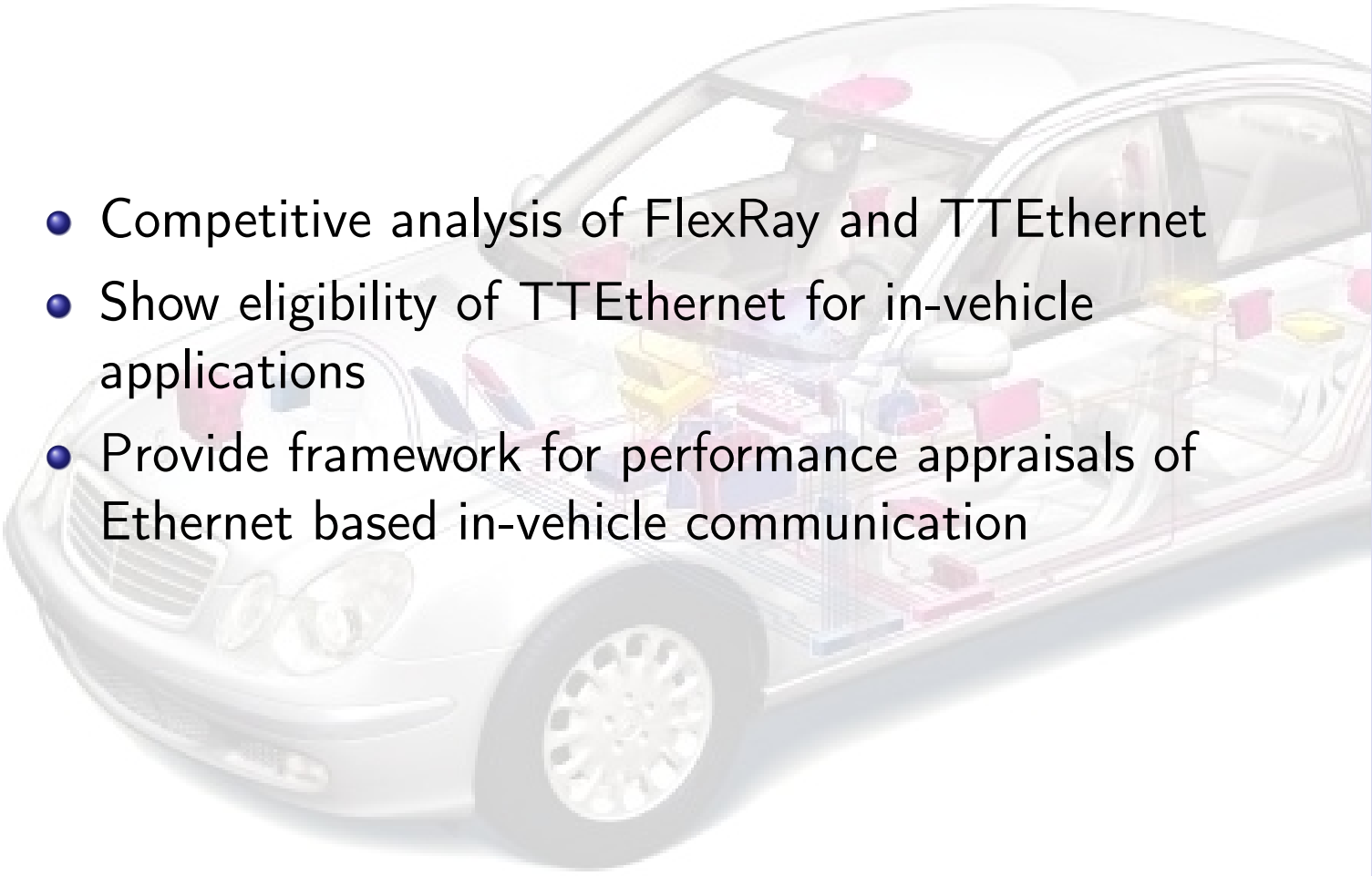
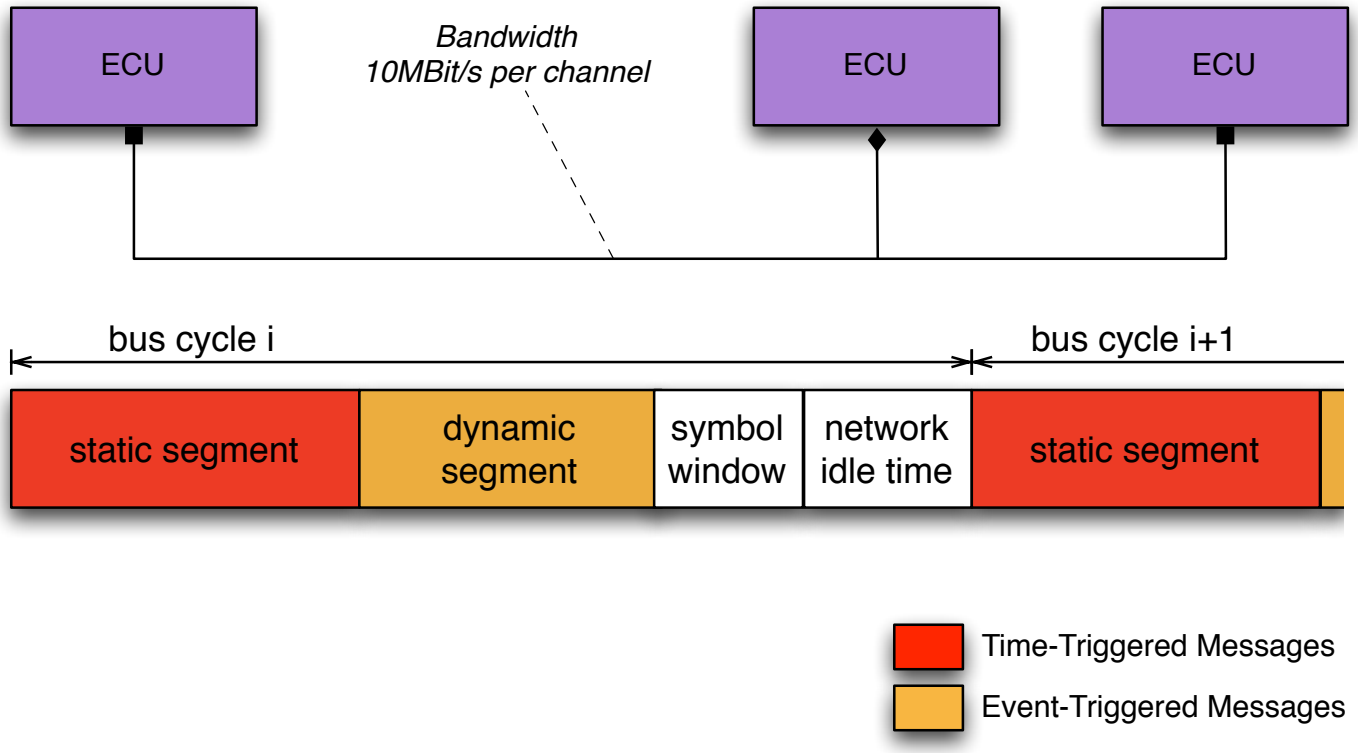
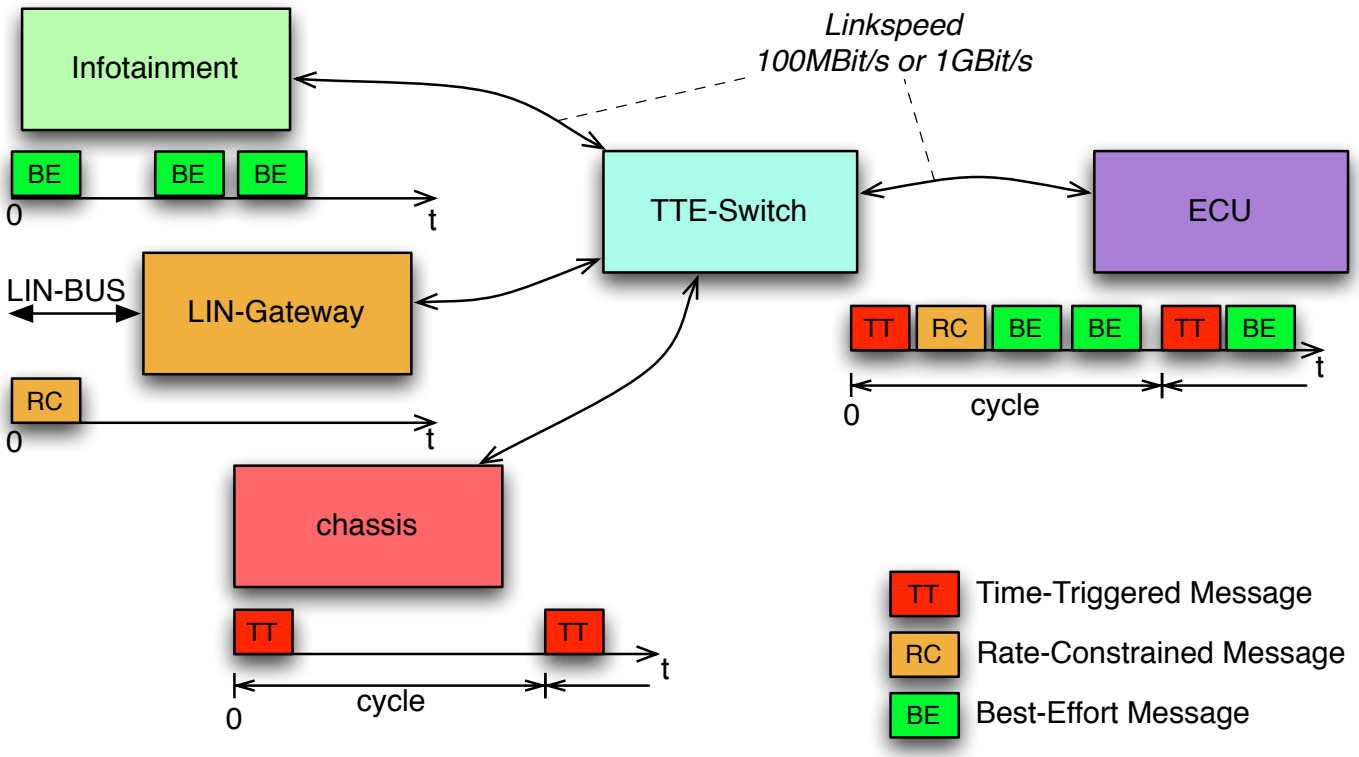
- Time-triggered Ethernet promises real-time and best-effort traffic in one backbone network
- Usage of components of the shelf
- Benefit from the expertise of the plenty Ethernet developers



- Competitive analysis of FlexRay and TTEthernet
- Show eligibility of TTEthernet for in-vehicle applications
- Provide framework for performance appraisals of Ethernet based in-vehicle communication


ECU
Bandwidth
10MBit/s per channel
ECU
ECU
bus cycle i
bus cycle i+1
static segment
dynamic segment
symbol window
network idle time
static segment
Time-Triggered Messages
Event-Triggered Messages

Background
TTEthernet

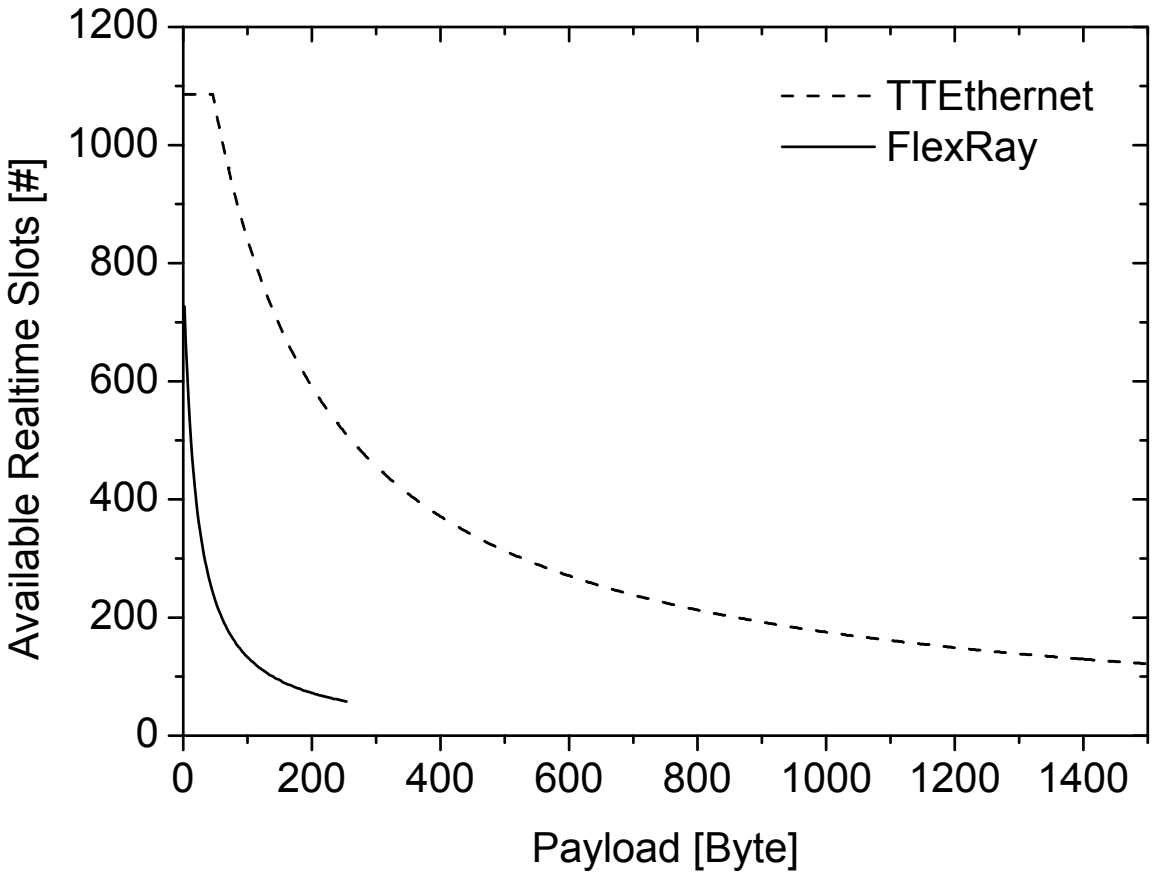


- Analytical framework that can be adapted to varying topologies
- Concrete results based on a sample configuration
  - Topology with two stars / switches
  - 16 ms cycle
- Latency and Jitter are calculated for the sample configuration
- Bandwidth is compared over various payload sizes

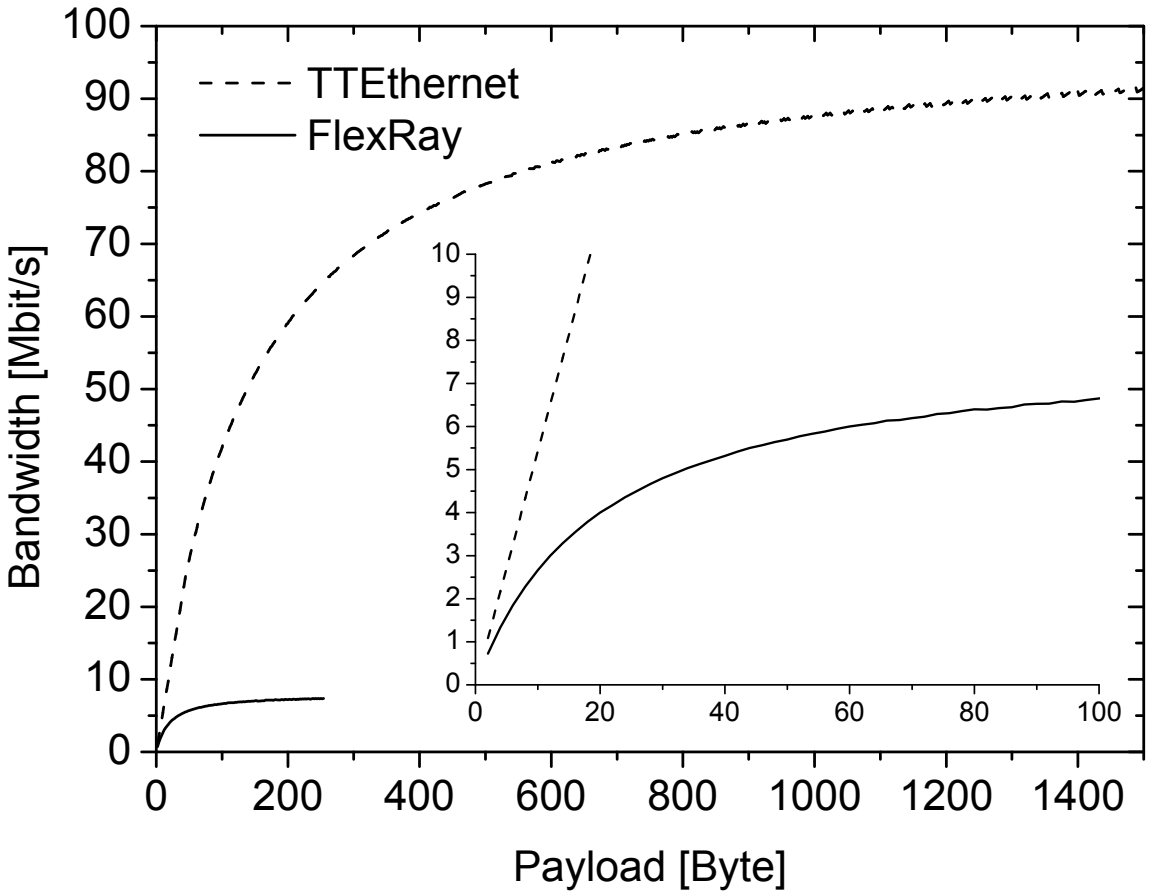
- The analytical results for jitter and latency of FlexRay and TTEthernet are comparable
- Switching delays in TTEthernet cause higher latency in large topologies
- Jitter is nearly unaffected by the number of switches in the network

	FlexRay	**TTEthernet**
latency min. payload	$12.2\mu s$	$24\mu s$
latency max. payload	$265.2\mu s$	$372\mu s$
jitter bounds	$6.4\mu s$	$< 10\mu s$

Results
Real-time slots at payload size



Results
Net bandwidth at payload size



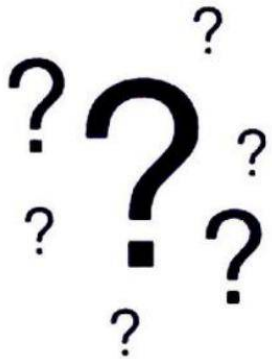
- TTEthernet allows varying payload sizes in the cycle and parallel message transmission

Conclusion

- FlexRay real-time traffic can be embedded in time-triggered Ethernet
- The TTEthernet correspondent of a fully utilised FlexRay configuration is utilised by approx 11%
- Especially for larger packages the bandwidth gain in time-triggered Ethernet is high
- Bandwidth utilisation can further profit from group communication

Outlook

- Currently we build a simulation framework for Ethernet based in-vehicle networks
- Future work will analyse event-triggered communication, segmentation and priority functionalities
- Further questions concern consolidation strategies for current in-vehicle bus systems.



Thank you for your attention