Service Oriented Architecture (SOA) and the Integration of Online Learning-based Applications

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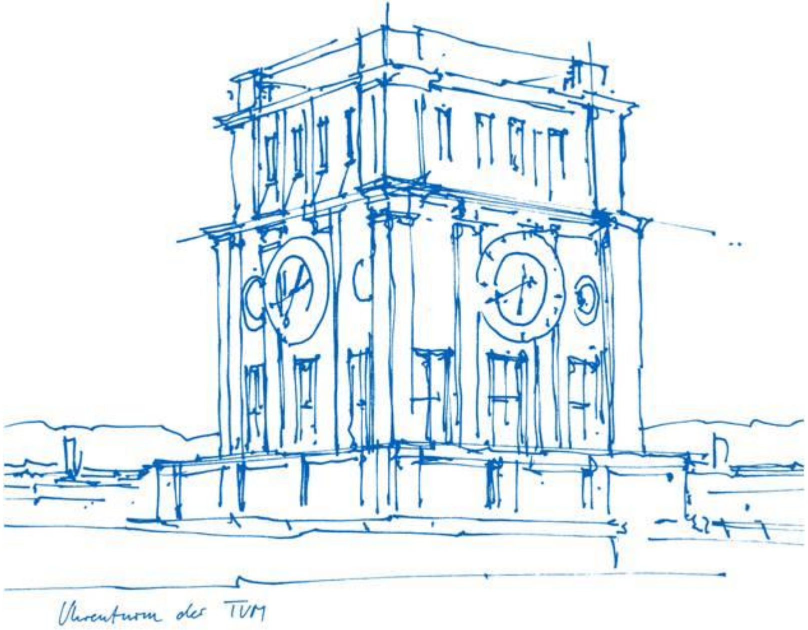
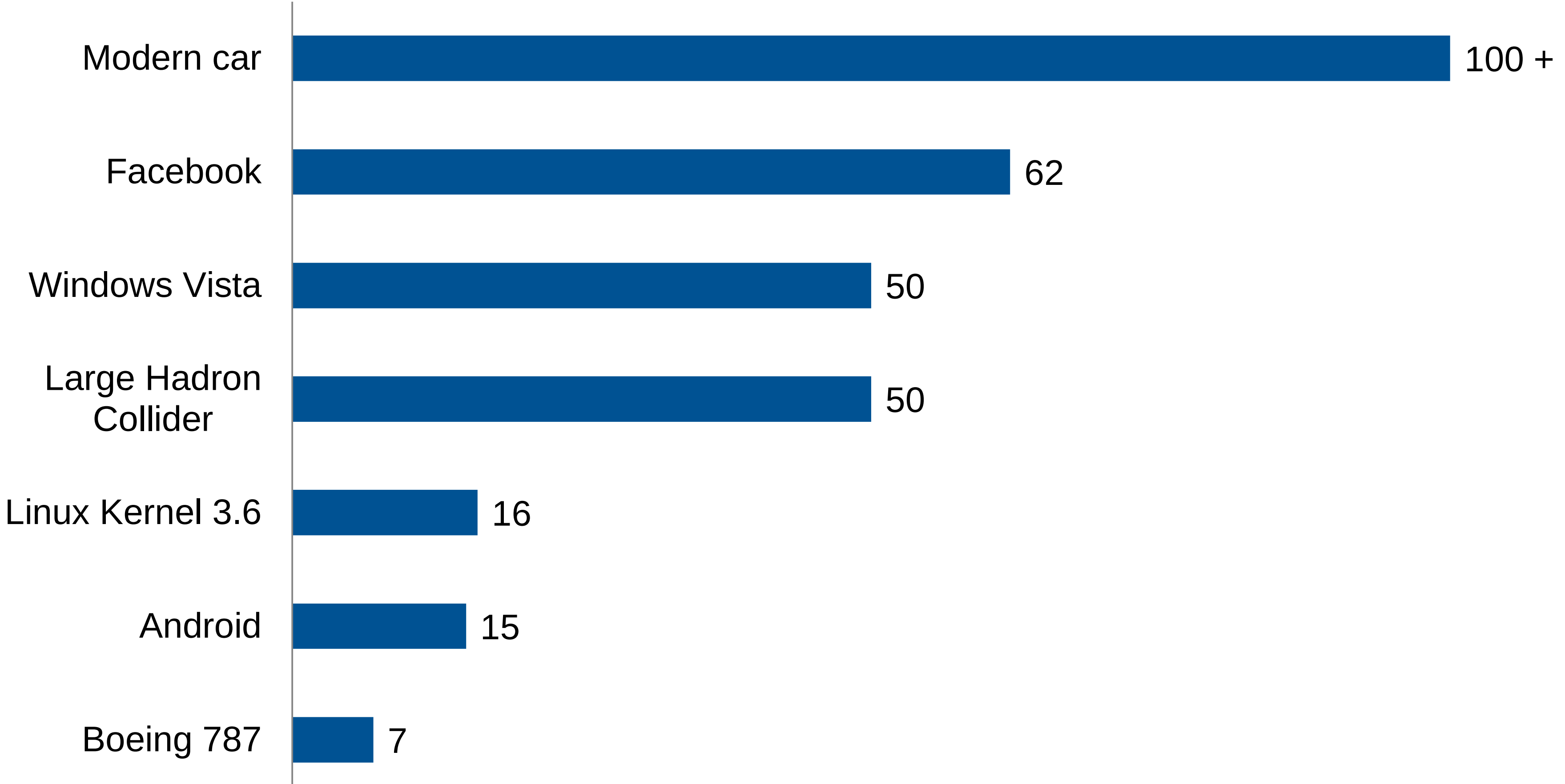
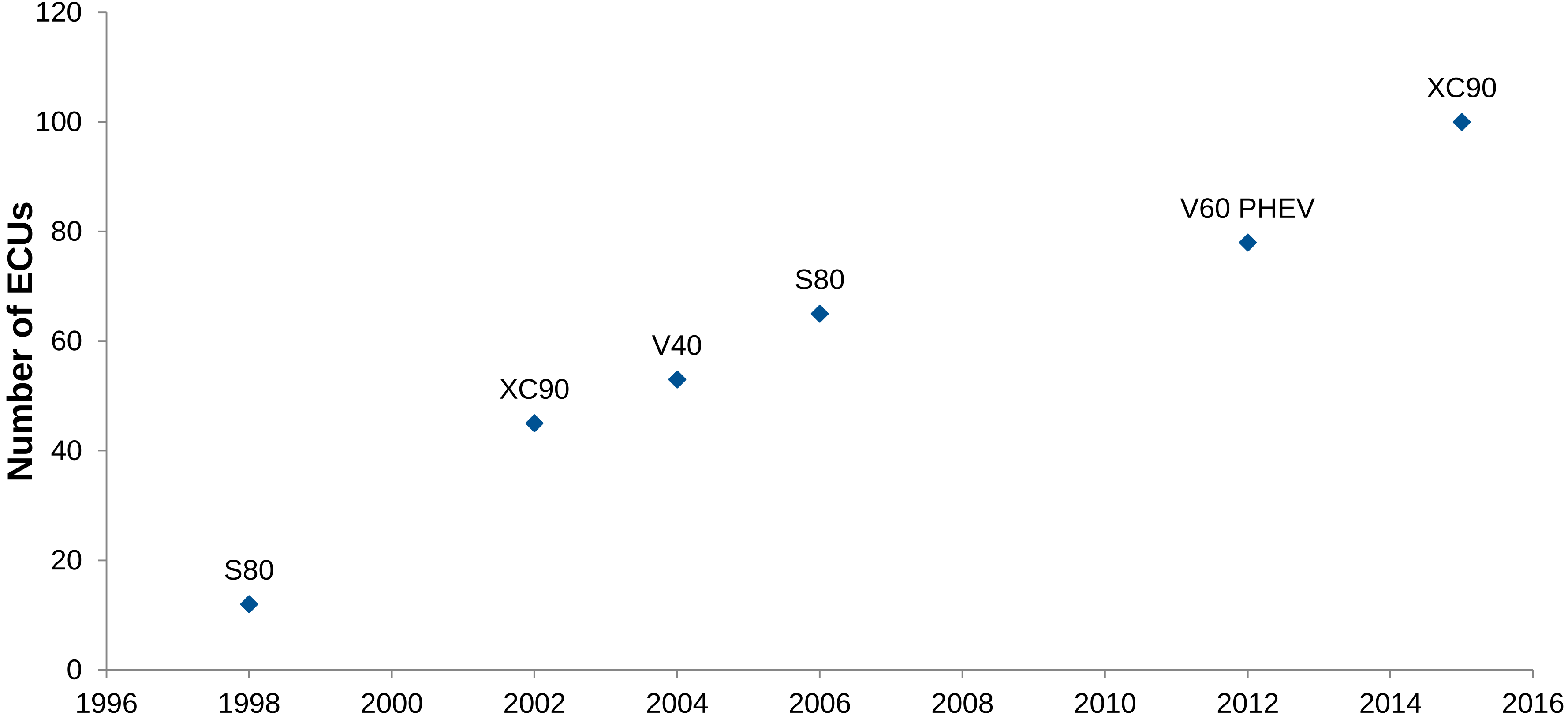


Outline

Software Size (Million Lines of Code)

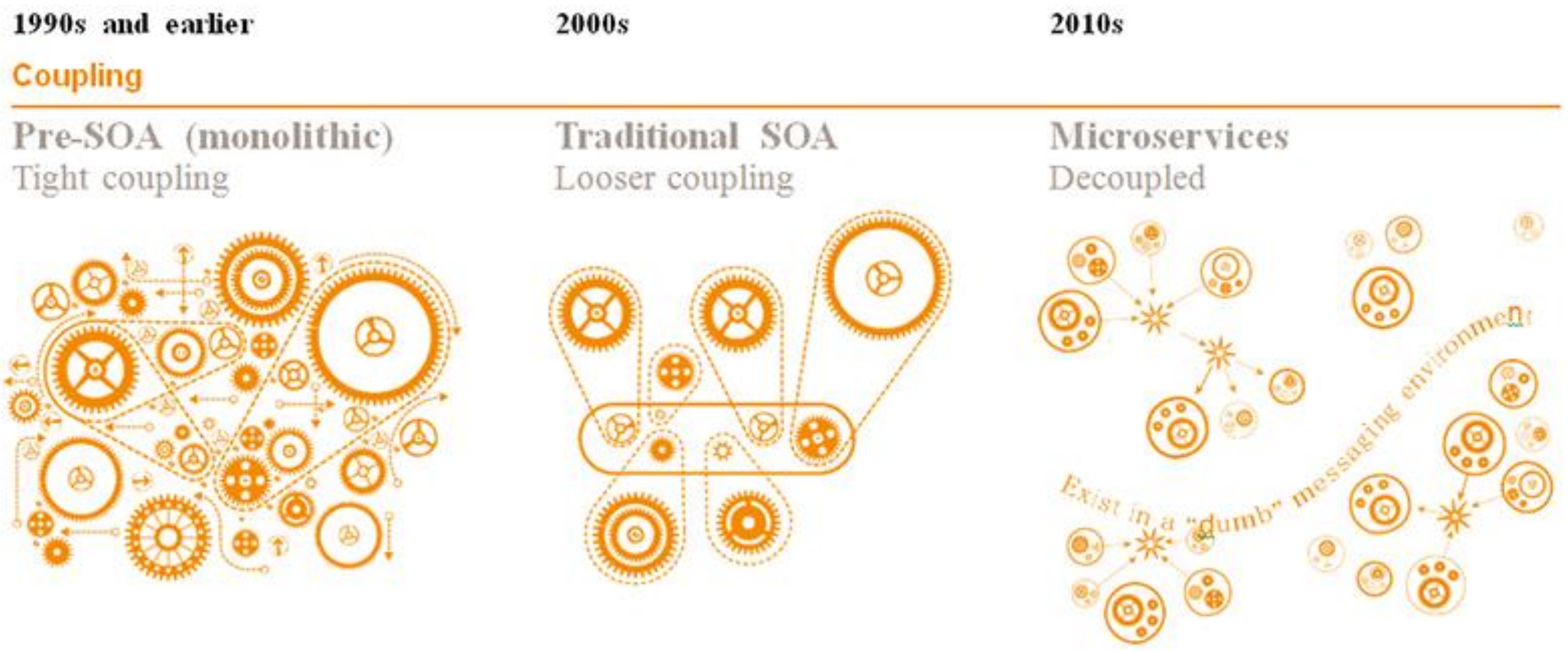


ECU Count Evolution at Volvo



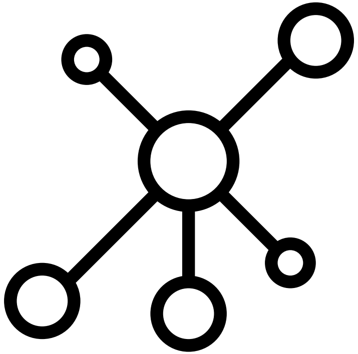
Outline

Evolution of SOA

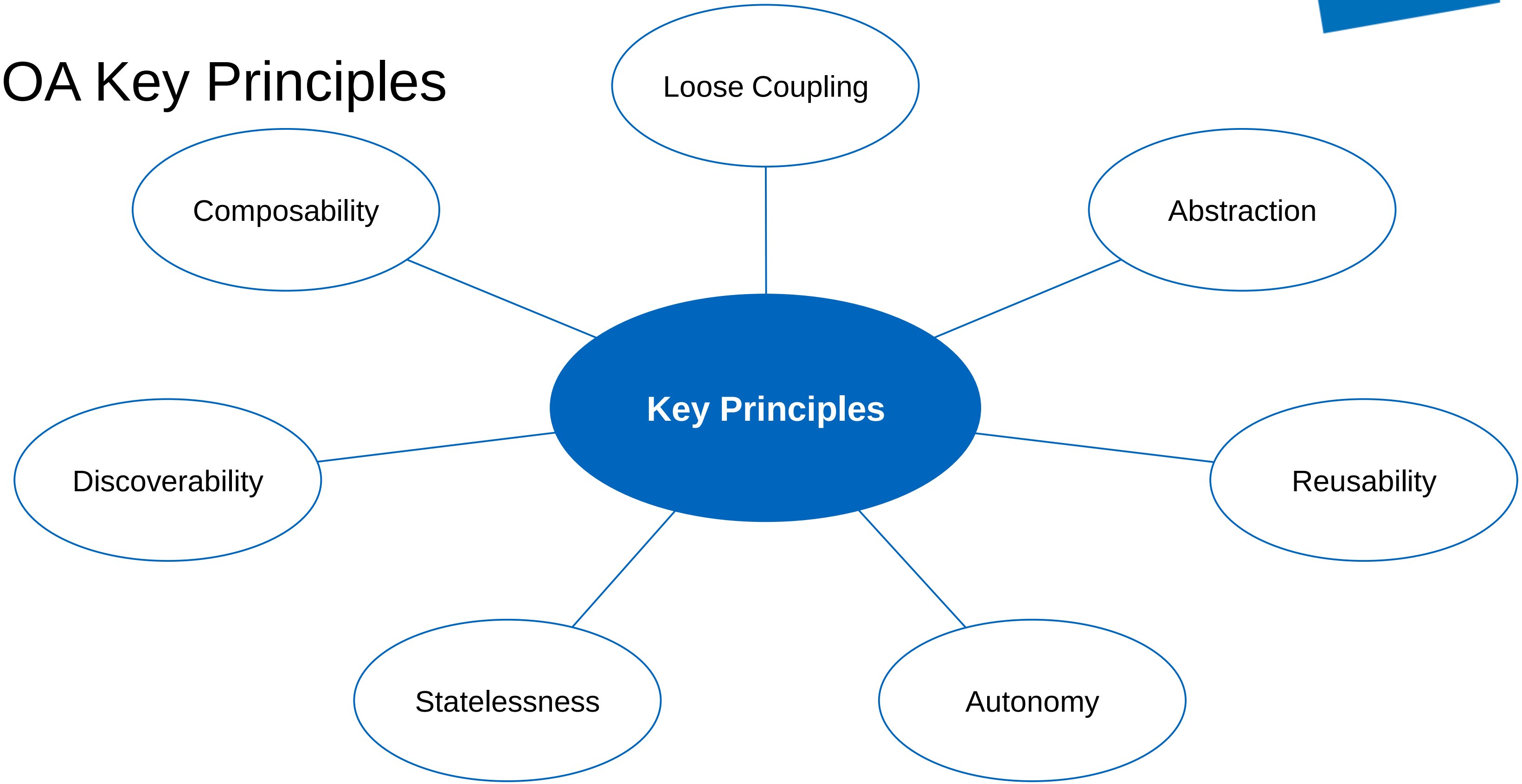


What is SOA ?

- Architectural pattern in computer software design
- Enables application functionality to be provided as a set of services
- Allows creation of applications that make use of software services
- Couples services loosely by using standards-based interfaces

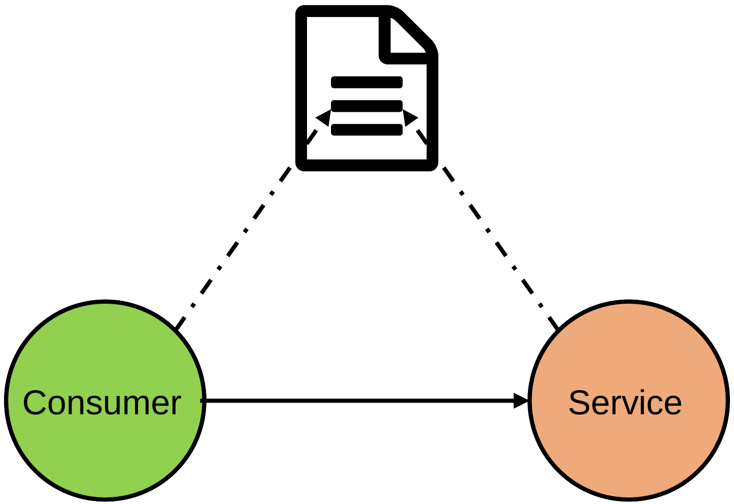


SOA Key Principles



Service Contract

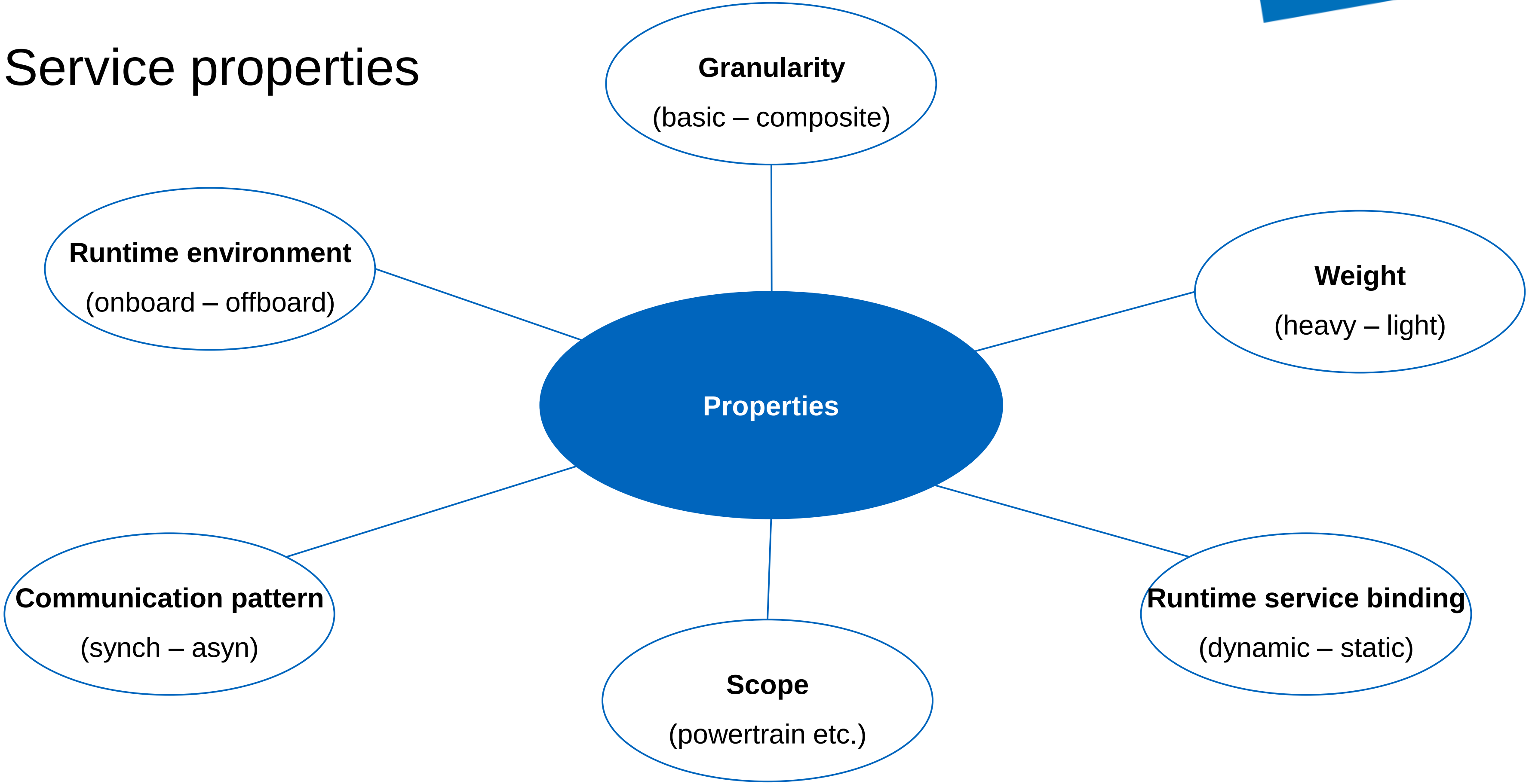
- Service Contract
  - Documents expressing meta information
  - Technical interface of service
  - Service Level Agreement (SLA) specifies quality-of-service features



Service-oriented analysis and design phase

Technology-agnostic		Technology-specific
Service-oriented analysis	Service logic design	Service implementation design
▪ Identify service candidates	▪ Identify service composition candidates	▪ Specification of service API ▪ Specification of service level agreements (SLA)

Service properties



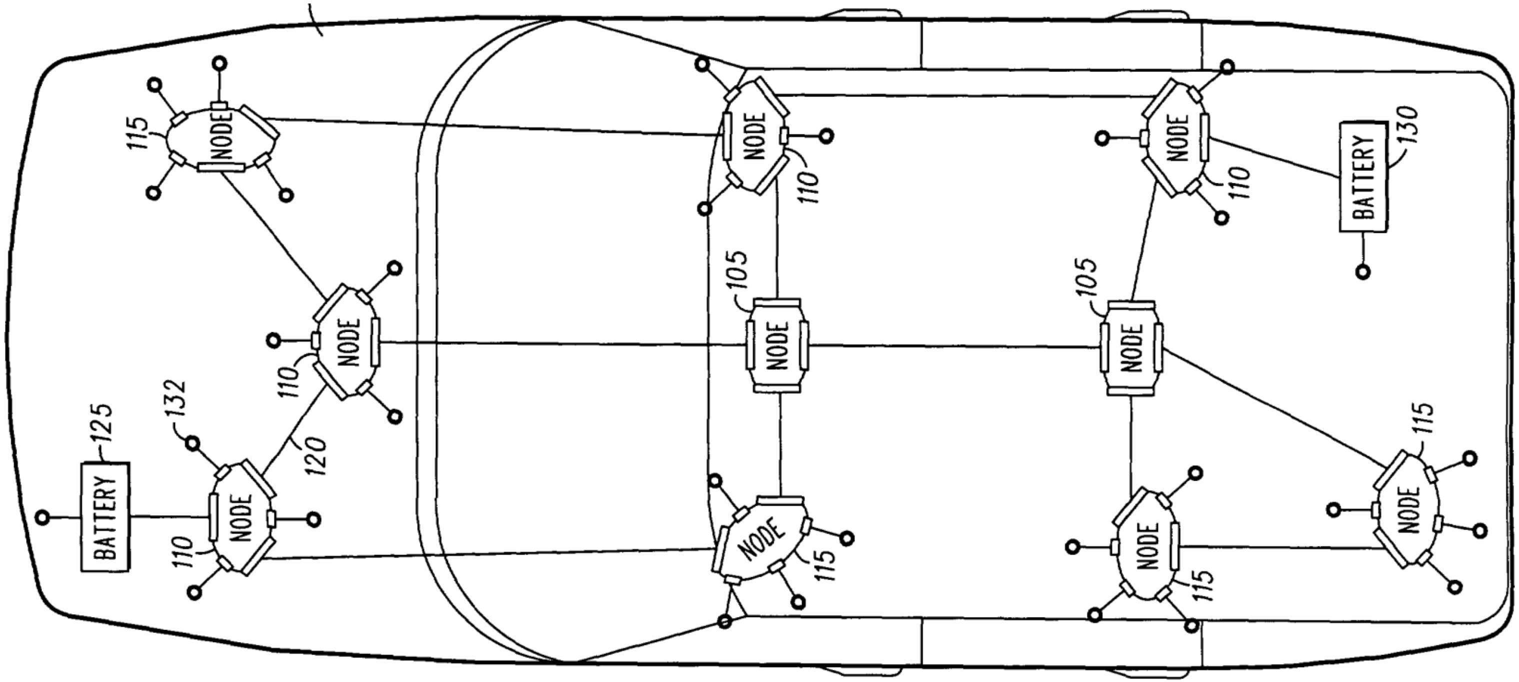
Outline

ECU Based Architecture

Drawbacks:

- Complex architecture
- Communication over different Bus Systems (CAN, LIN)
- Mass ~ 50kg
- No central data gateway

Zone Architecture



Combining Zone Architecture with SOA

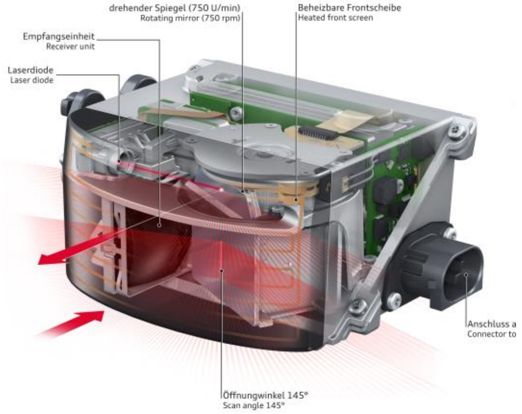
Simpler architecture

- Clear interconnection of services
- High level of abstraction
- Logical composability
- Central data fusion place
- High bandwidth for computer vision and machine learning tasks
- Upgradability of hardware and software (gpu sockets / over the air update)

SOA enables Hardware Independence

- Different types of Sensors:
  - Ultrasound
  - Lidar (Laser Scanner)
  - Radar
  - Camera

- Upgradability of sensors:
  - Camera cheapest
  - Later expanded with lidar



Advantages of SOA for AI in cars

- More structured Online learning implementation → cheaper
- Faster development
- Developing new features/algorithms for customers after car sale

Examples for autonomous car algorithms:

- Computer Vision
- Sensor fusion
- Trajectory planning

- Parallelizable
- Computational Complex

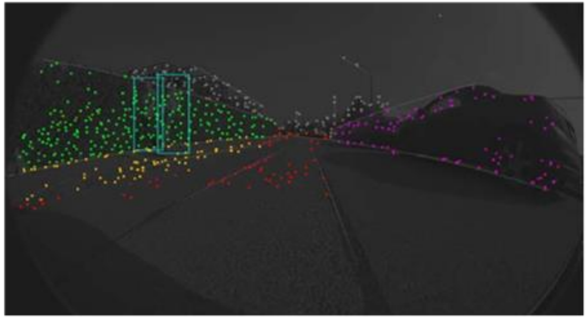
Computer Vision Computational Complexity

Nvidia estimation:

Feature Detection / Tracking
30 GFLOPS (30 Hz)

Object Recognition
180 GFLOPS (30 Hz)

3D Scene Interpretation
280 GFLOPS (30 Hz)



Online learning in the car or in cloud?

On-car training not yet feasible for safety critical functions:

- On-car training:
  - Danger of malicious learning
  - Need to install expensive hardware → car cost

- Off-car training:
  - Store produced data
  - 5G connection for sending training data to server

Outline

Functional safety overview

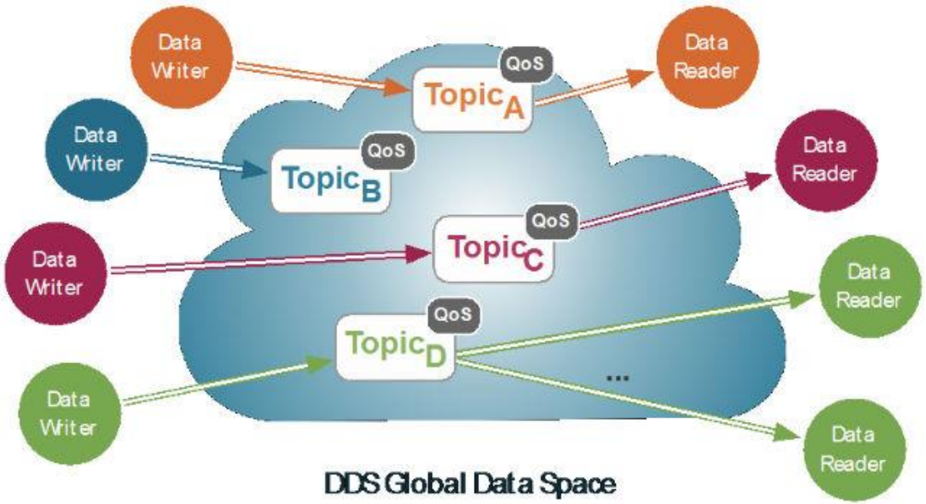
- Safety defined as minimization of risk and uncertainty
- Functional safety of automotive software addressed by ISO 26262
- Automotive Safety Integrity Level (ASIL)

Severity class	Probability class	Controllability class		
		C1	C2	C3
S1	E1	QM	QM	QM
	E2	QM	QM	QM
	E3	QM	QM	A
	E4	QM	A	B
S2	E1	QM	QM	QM
	E2	QM	QM	A
	E3	QM	A	B
	E4	A	B	C
S3	E1	QM	QM	A
	E2	QM	A	B
	E3	A	B	C
	E4	B	C	D

Middleware crucial for ASIL rating

- Data Distribution Service (DDS)
  - Scalable, distributed, interoperable data sharing
  - Pub / Sub System

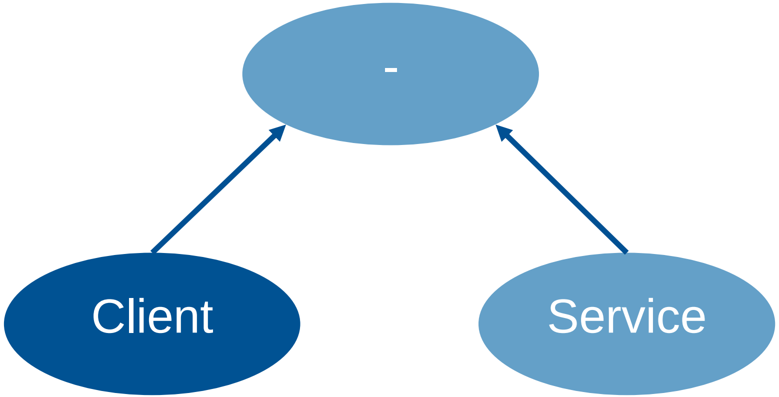
- Time-Sensitive Networking (TSN)
  - Real-time communication over Ethernet
  - Guarantees of delivery



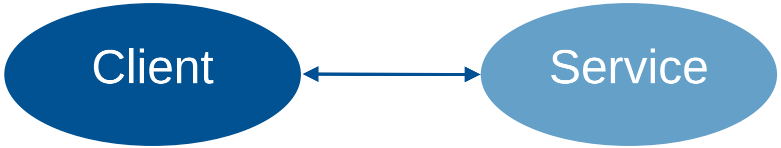
Checking time constraints is hard

- Services may be deployed on different platform
- Bring your own device
- Assume the worst case
- Enforce static service binding

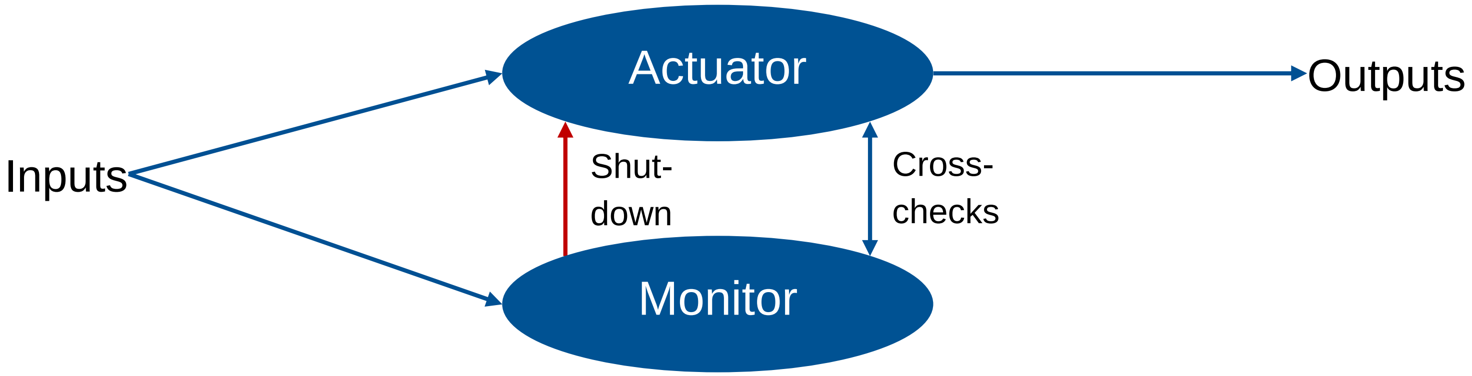
Dynamic service binding



Static service binding



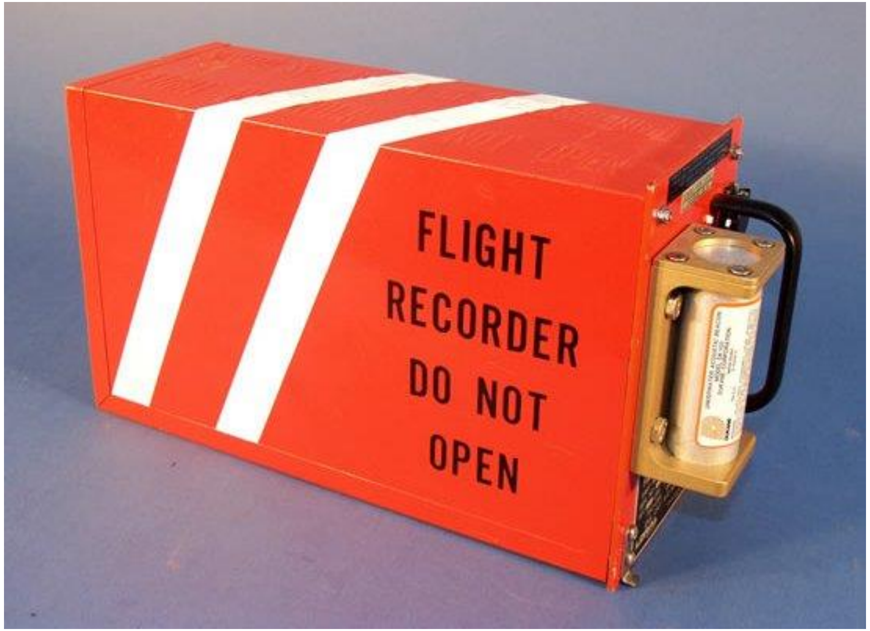
Monitor / Actuator services



- Actuator designed on low ASIL
- Vehicles have short failover missions
- Global Scope:
  - High-ASIL monitor service
  - Other services run low-ASIL

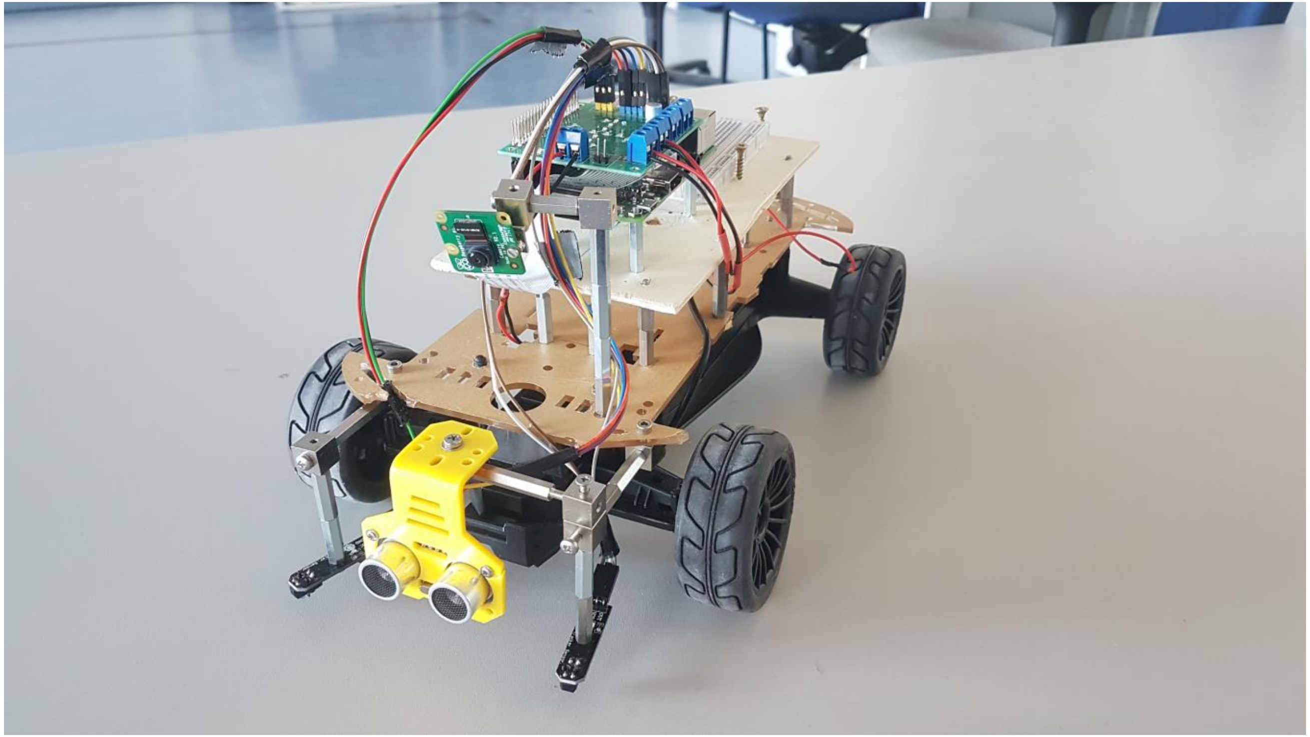
Black Box service

- Accident reconstruction data
- Important for legal issues
- Safety assurance argument
- Valuable training data
- Fits in zone architecture
- Log DDS



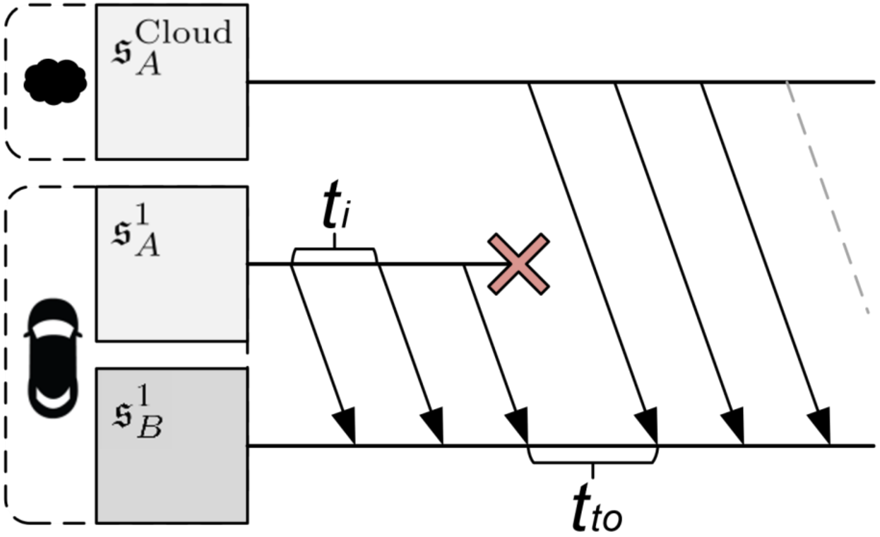
Outline

Autonomous driving platform



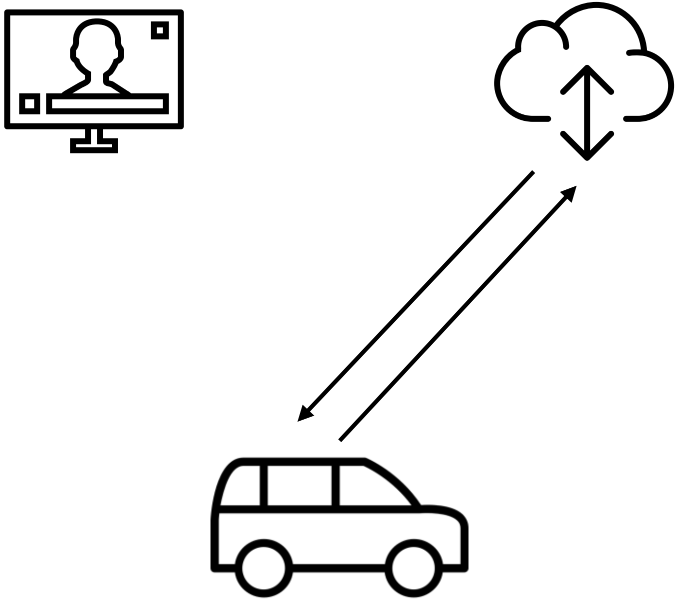
Failover test

- Failover test from Kugele et al.
  - Failover time t_{t0}
  - Response interval t_i
  - Service deployed in cloud s_A^{Cloud}
  - Service deployed locally s_A^{Local}



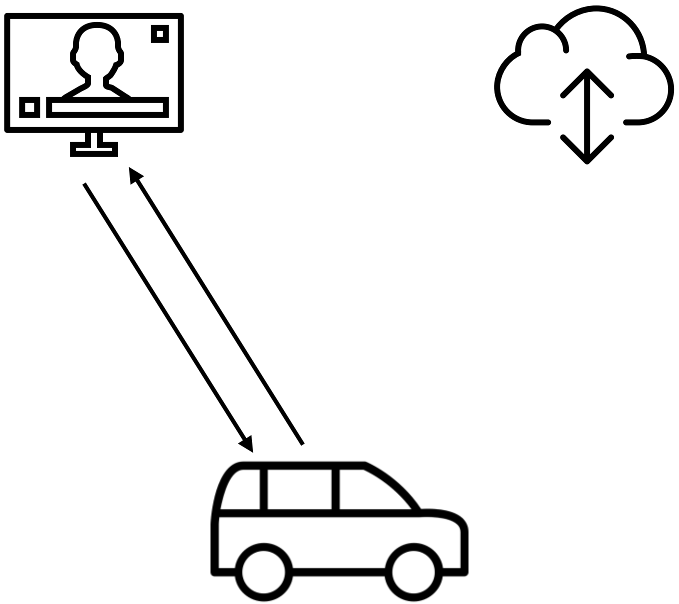
Implementation Cloud Service

1. Car sends request to cloud service over the internet
2. Google Server computes response
3. Car receives response over internet



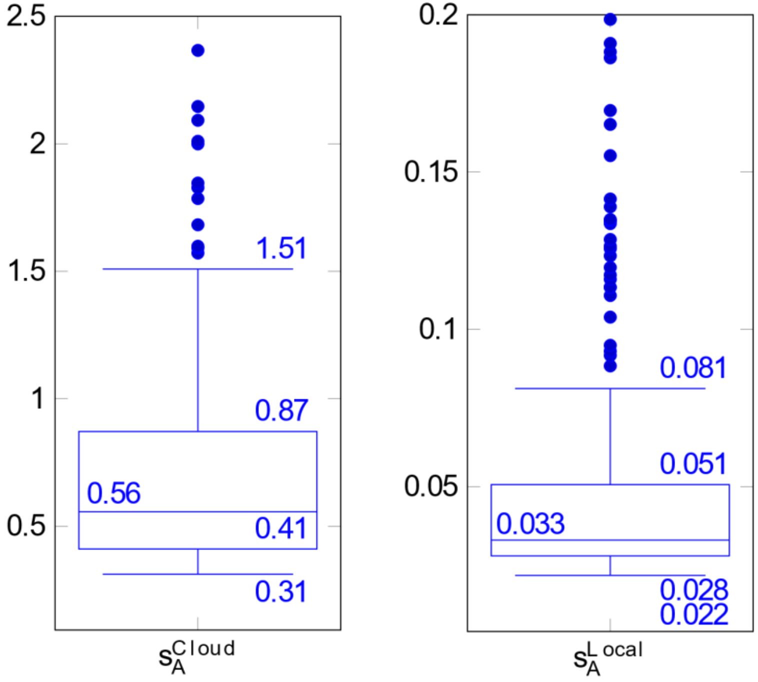
Implementation Local Service

1. Car sends request to local service over Wi-Fi network
2. Local Tomcat Server computes response
3. Car receives response over local network



Measurements of failover time

	$t_{i,cloud}$	$t_{i,local}$
mean	0.740	0.066
median	0.557	0.033
max	5.446	1.830
min	0.312	0.022
std	0.572	0.167



Implementation Result

- Median Cloud takeover time 859ms
- Median Local takeover time 335ms
- Both not real time capable
- Worst case analysis would clearly lead to crash
- Cloud service one order of magnate slower than local service
- Cloud service not suited for safety critical failover

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Outline

Conclusion

- SOA for hardware independence
- SOA improves deployment and development
- Cloud services no real time guarantee
- High ASIL monitor service for failover initiation
- Middleware has to support TSN and DDS
- Dynamic binding in safety critical functions not possible

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Thank You for Your attention!

Any Questions?