Architecture Transition Towards a Future Architecture Thinking at Volvo

2021-03-01

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- Volvo Group Trucks Technology
- Offical role at Volvo:
  - Logical Architect (main focus is ALL application software for trucks)
  - Global Technology Specialist for the AB Volvo group within architecture
- Graduated: 1987
- At Volvo since: 2008

Volvo Group

Main focus of today presentation, but it does not mean that its use is limited to this!

General Introduction

Improvements do not come without a change

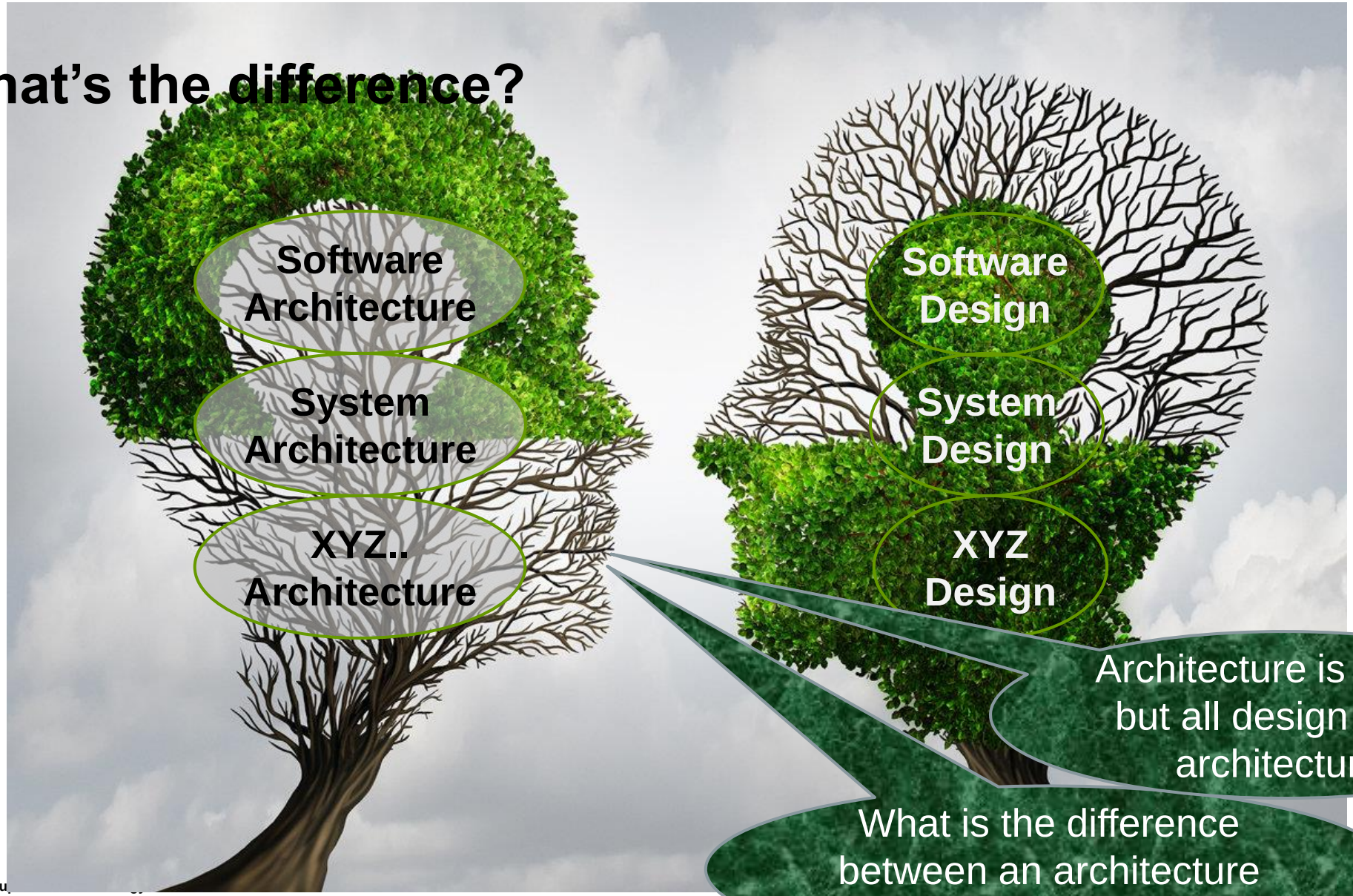
2021-03-01

What ”Architecture” Evokes!

How does it come that we use the term ”Architecture”?

The terms **Architecture**, **Architect** and **Architecting** come with a baggage.

What's the difference?



What ”Architecture” Generally Evokes!

Changing the style is quite expensive

”Architecture Transition”

A typical style from the 1940’s

Why change?

Maintenance cost, Energy consumption, Larger family, Very dark, ...

A typical style from the 2010’s

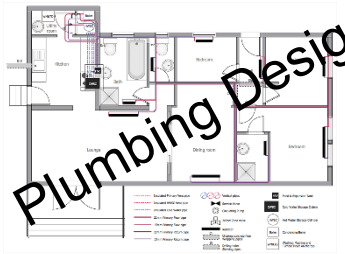
What ”Architecture” Generally Evokes (cont.)!

An architect’s sketches define fundamental properties of the building.

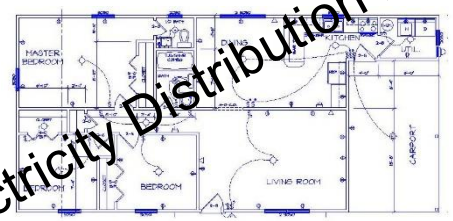
”Architetural Style”

”Soft Properties” (Aestics)

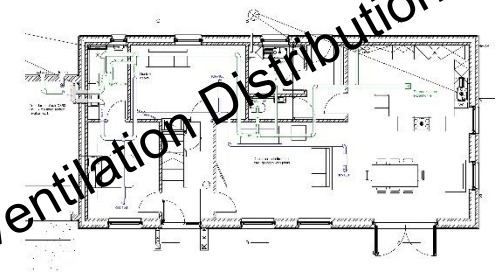
The architecture drawings works a **framework** for various kinds of design to relate to.



Plumbing Design



Electricity Distribution Design

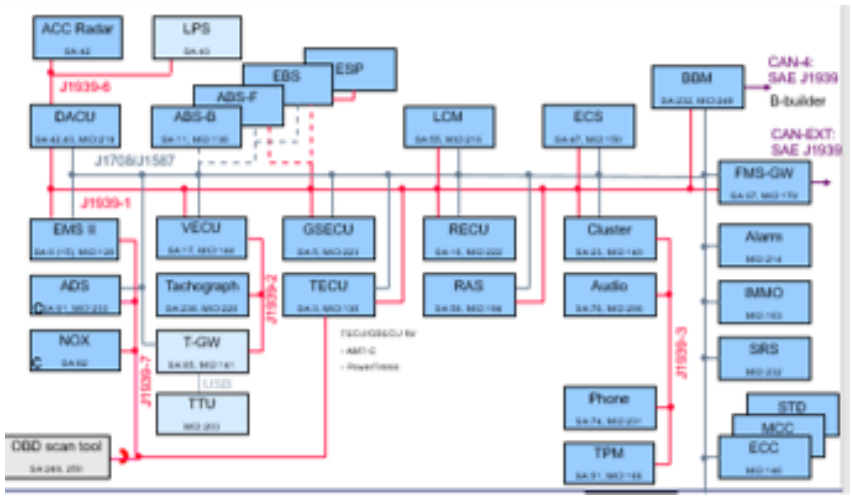


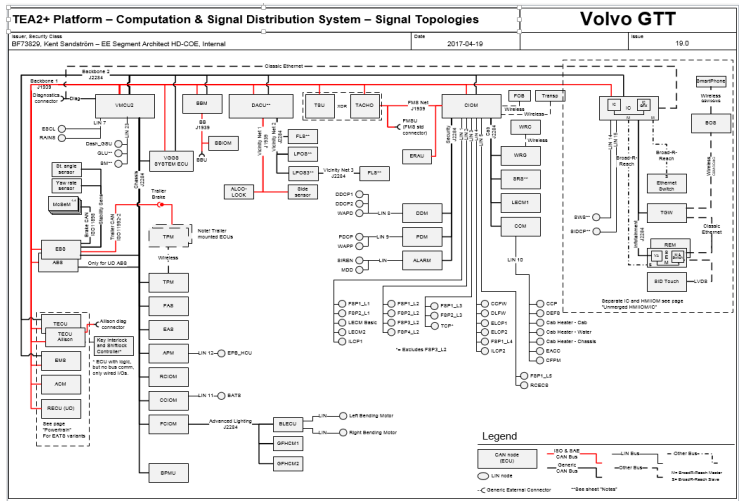
Ventilation Distribution Design

... Design

What ”Architecture” Evokes in AUTOMOTIVE!

Classic architecture thinking in automotive companies: Computers (ECUs) connected with CAN or LIN busses ...



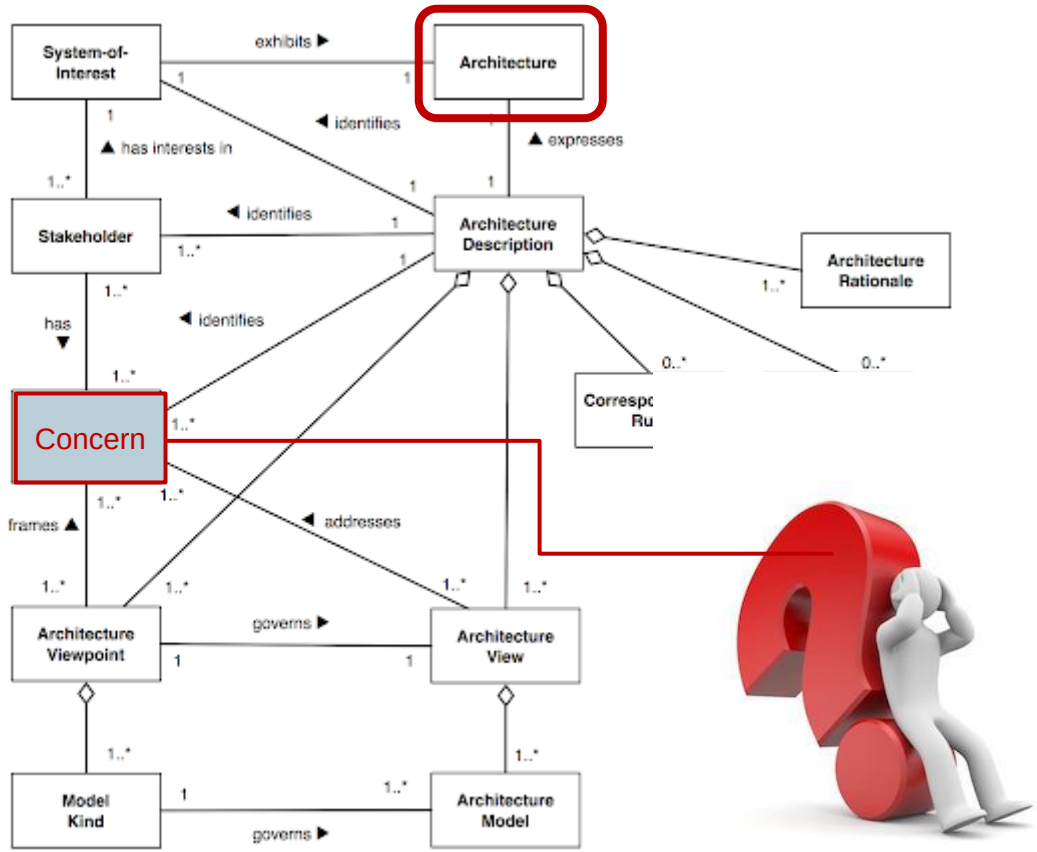


... is far away from modern architetcure thinking!

Architecture defintion according to ISO/IEC/IEEE 42010

Fundamental concepts or properties of a system embodied in its components, their relationships to each other and to the environment and the principles guiding its design and evolution.

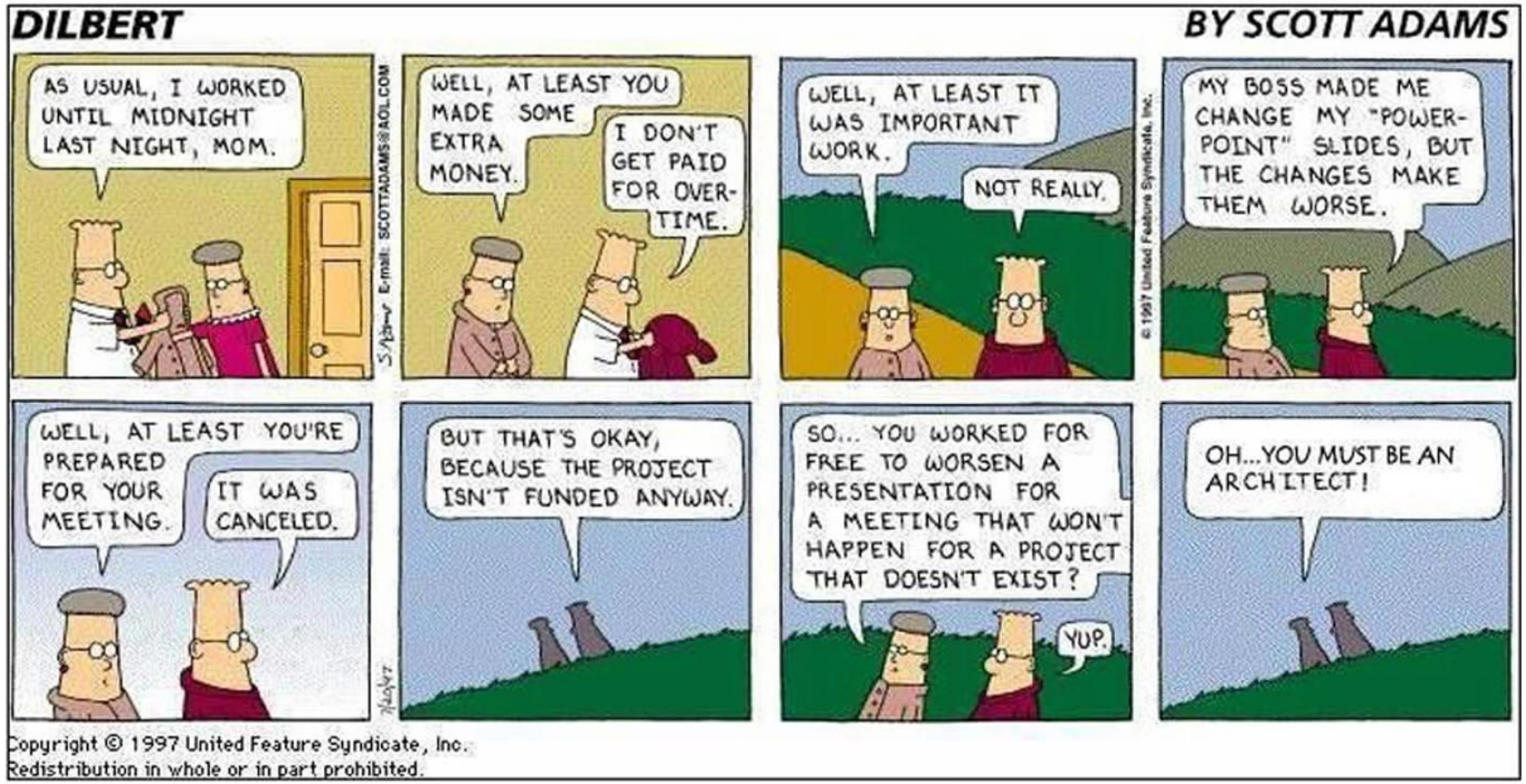
- Architecture always point at a specific system
  - What is treated as a system is in the eye of the beholder!
- Architecture & Architetcure Description are differnt things
- As for building you can have differnt perspectives (viewpoints) at a system



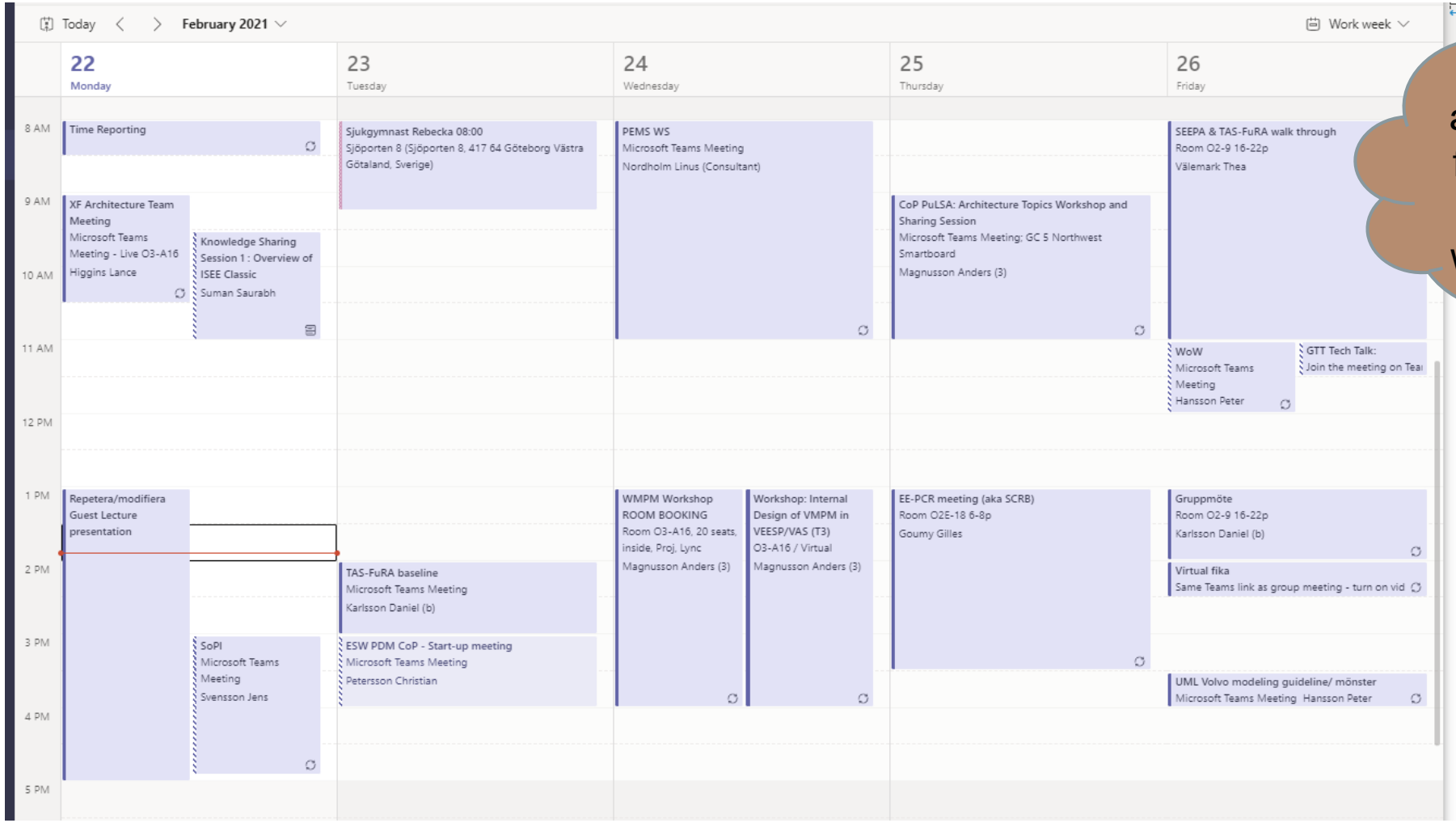
Architecture vs. Design

- Design goodness flows from the ability to do architectural reasoning, enabled by:
  - the existence of an architecture, in top of the design
  - the internal regularity (conceptual integrity) of the architecture
    - That means; a small set of design ideas (principles, patterns) is used throughout the design.

Just so you know how it is to work as an architect



Work as an architect: A typical week for me



Unfortunatly there aren't much space for coding or even doing thought work at your desk!

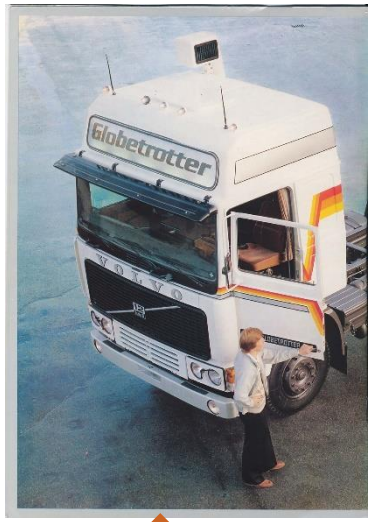
Why Change –
A Selection of Architecture Challenges?

Improvements do not come without a change

2021-03-01

What is going on ... one snapshot

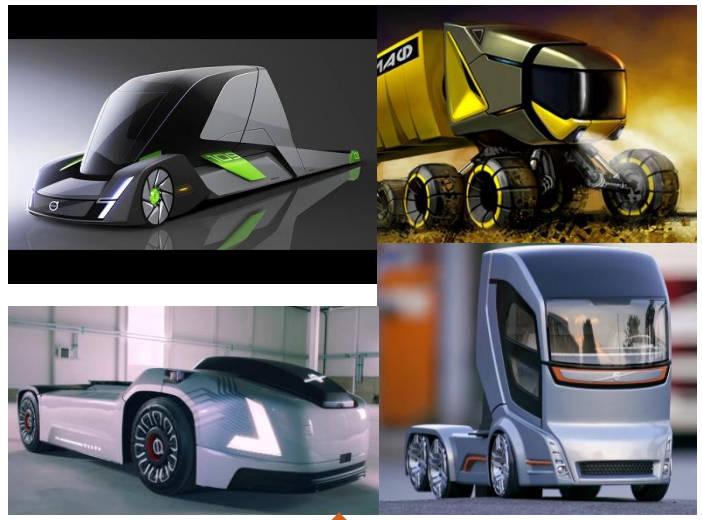
”Architecture” @ Volvo Group Trucks Technology!



Mechanically defined vehicles!

”Architecture Transition”

Why change?



Software defined vehicles?

... and specifically Architecture Challenges

- Architecture is not just done for fun, but <u>you want to achieve something</u> specifically such as:
  - lower effort to add new features,
  - support an application on multiple run-time platforms,
  - make it possible to continuously provide new features to applications already in operation
  - …
- We talk about **architectural concerns** (quality attributes or –ilities)!

… and many of these are contradictory and orthogonal

Some architecture worries has been identified!

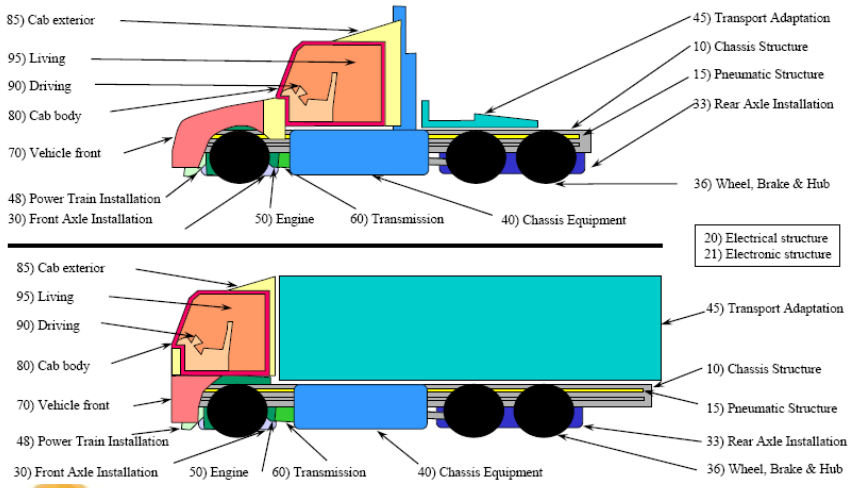
I will present some of these!

Geometry-Oriented Mindset Dominates @ Volvo GTT

We are bound to an existing **Thought Style**

Geometric-Oriented Vehicle Module Structure

Volvo:1927



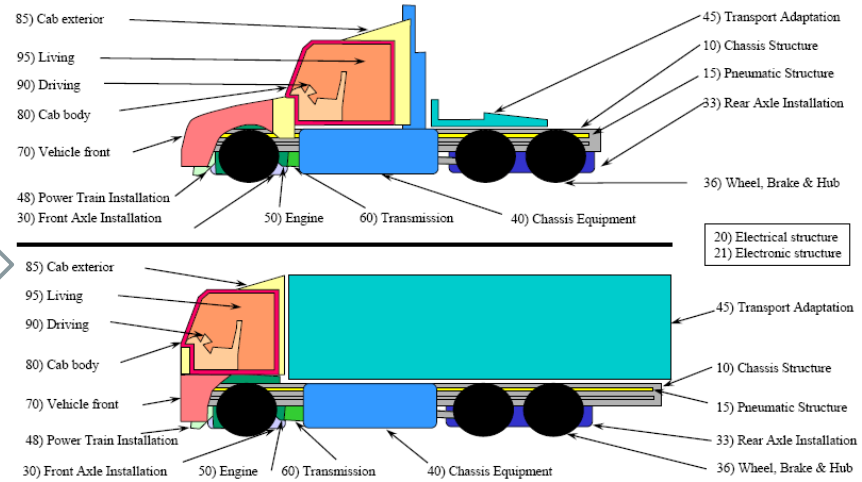
Mechanic Engineer Collective

Geometry-Oriented Mindset Dominates @ Volvo GTT

It is hard to find a natural place for

- **Brake Blending,**
- **Cruise Speed Controller,**
- **Cruise Distance Controller,**
- **Lane Keeping Controller,**
- **Energy Recuperation,**
- **Automatic Window Cleaning**

... in this geometry-centric mindset!



A geometry-oriented mindset is rather poor for software reasoning and for functionality reasoning in general!

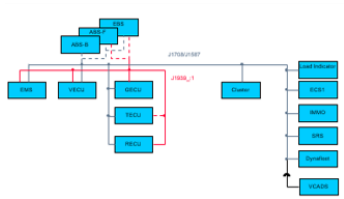
Electronic Centric Development since 197?

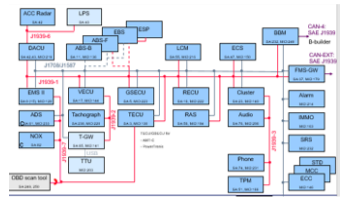
TEA “Platform”

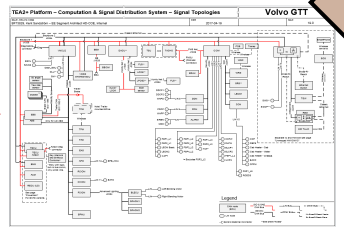
TEA2 Bridge Plan “Platform”

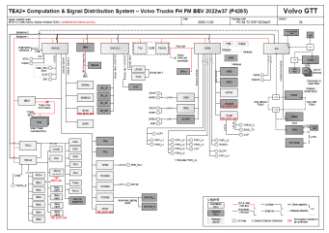
TEA2+ “Platform” /T1

TEA2+ “Platform” /T2









- Electronic (ECU) centric for very long time!
- Focus on wiring mechanic boxes together
- Topology is **THE** “architecture”

Concern: Electronic vs. Software Values

Different kinds of values!

Fundamentally diffrent development cycles (Changeability)

Simulink

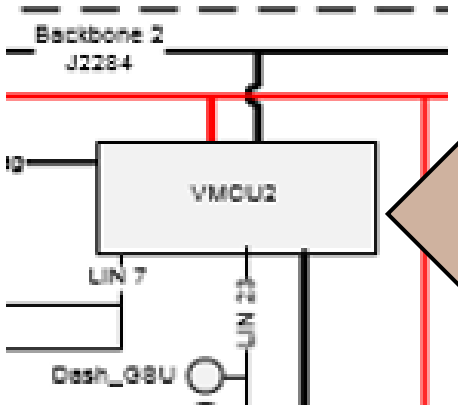
Powerpoint

Visual Code

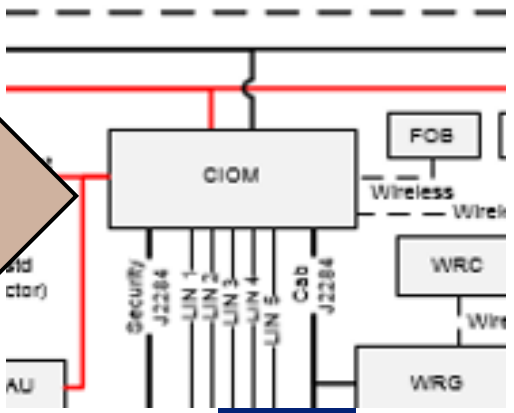
MS Visio

Creating operational values

What is the value of this computer?

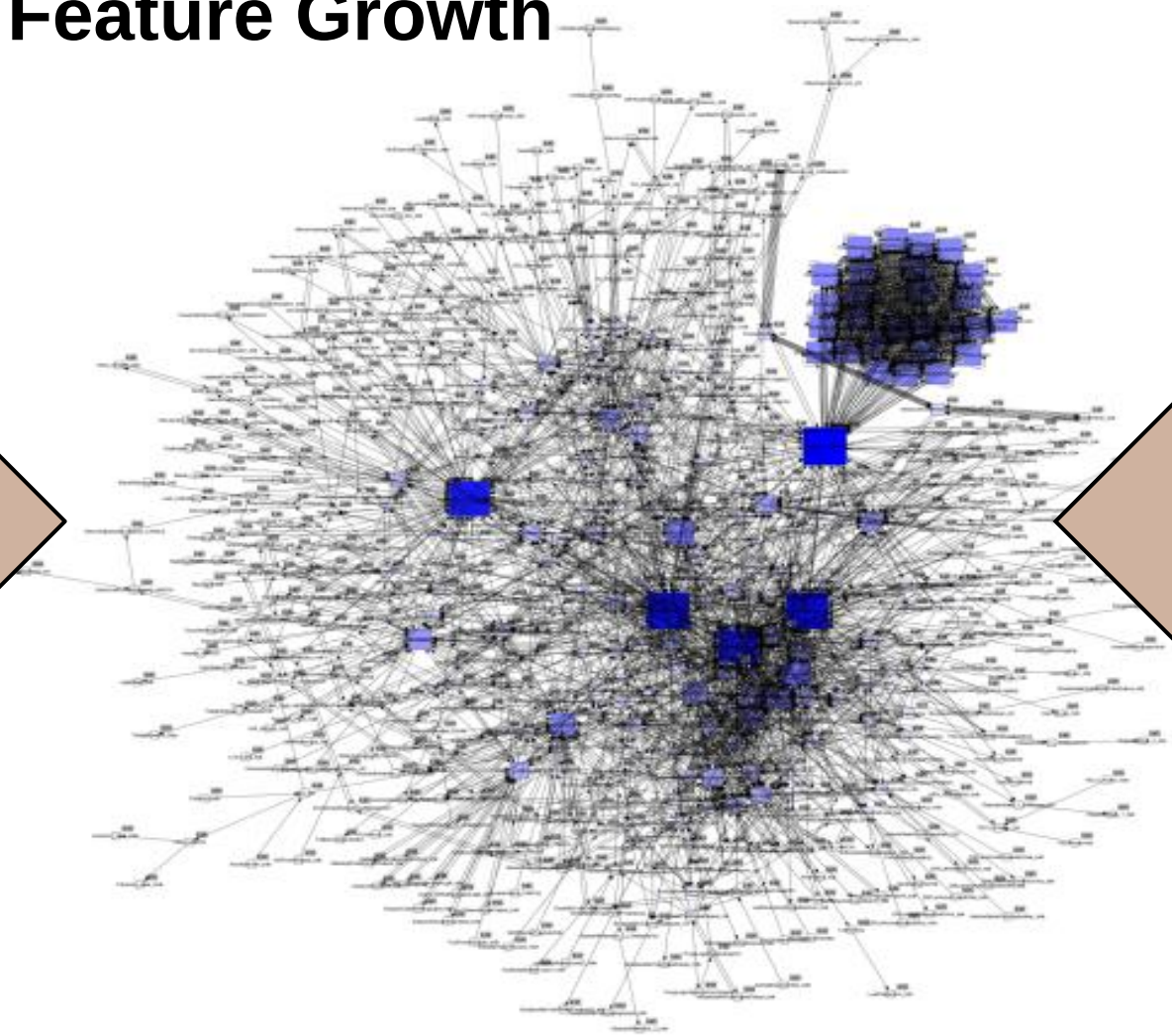


What happen if your focus is on these computers ?



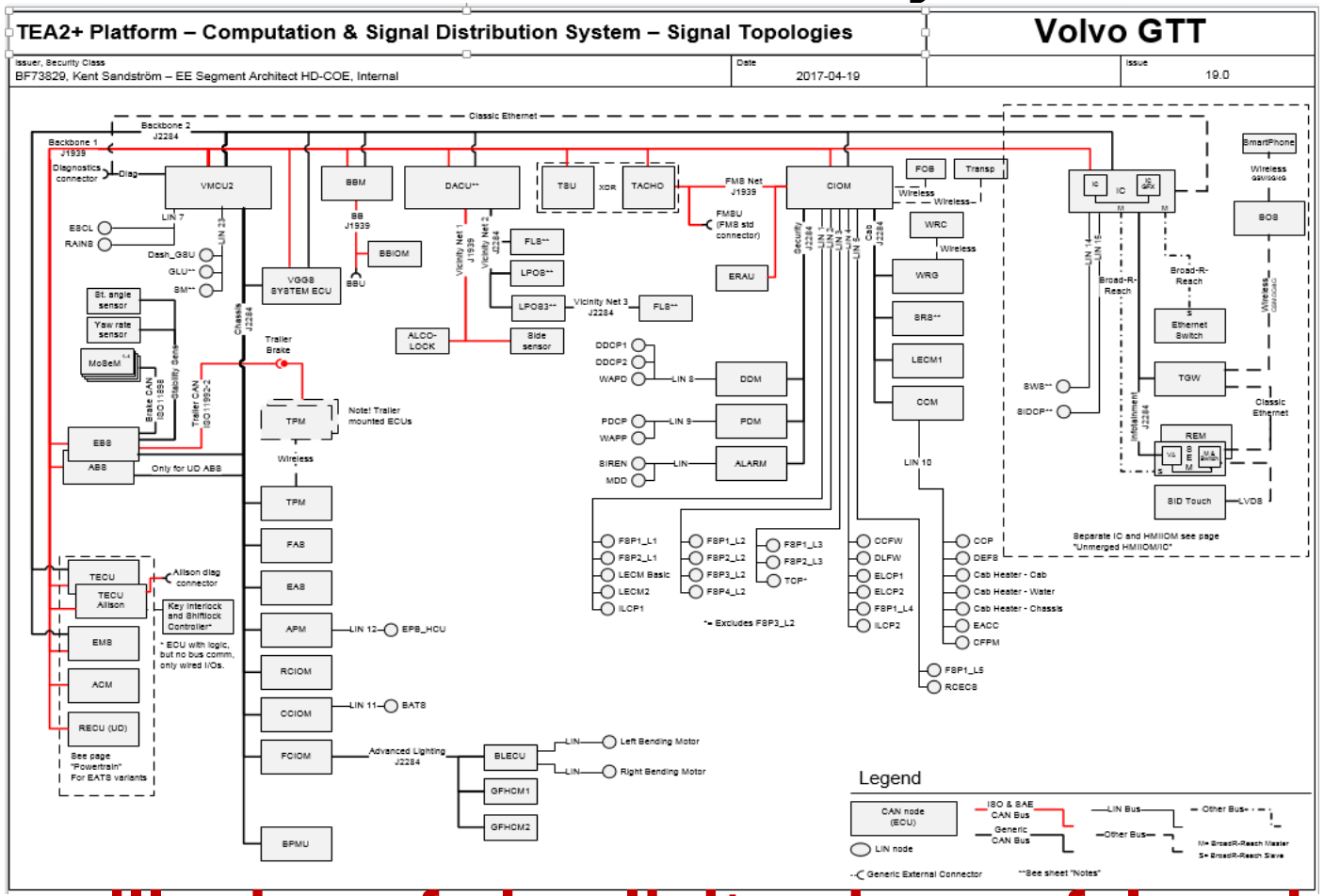
Accidental Feature Growth

”Accidental Architecture” or ”Ad-hoc Architecture” ≈ No Architecture



What is the style of this?

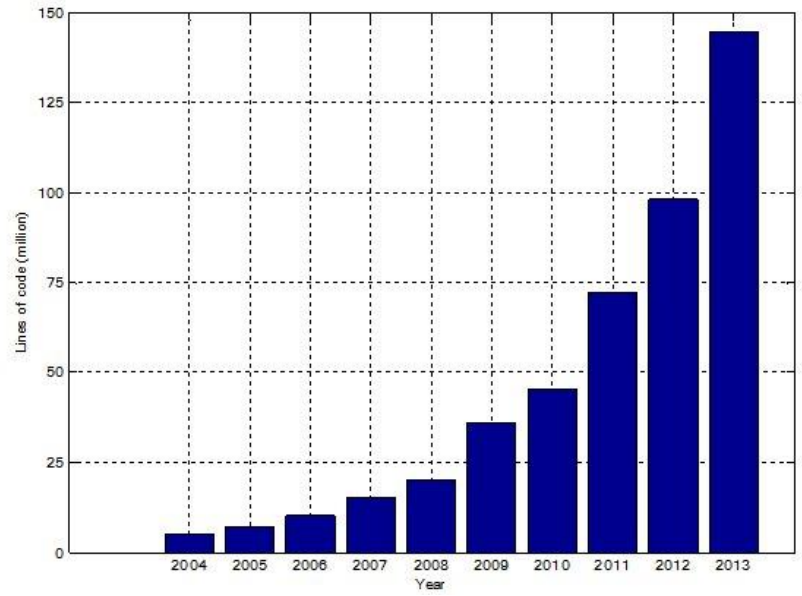
... and software is not really covered in topologies ...



... an illusion of simplicity gives a false picture of the complexity!

Value Creation Through Software => Size

It is application software that provides ”features” that creates useful values for users!



Rapid increase in automotive software

(million lines of code)

© https://www.researchgate.net/publication/301227984_Perspectives_in_Automotive_Embedded_Systems_From_manual_to_fully_autonomous_vehicles/figures?lo=1

There will not be less software (cont.) ...

Area/Tech. Trends

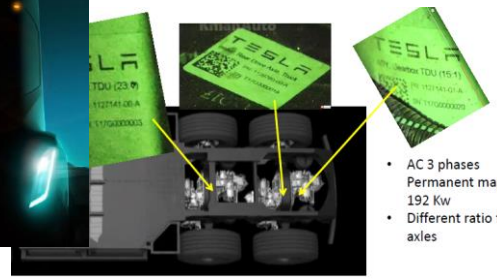
Market & Business Needs

Daimler: The entire conventional drivetrain being replaced by a new electrically driven rear axle with electric motors

eCascadiauses wheel-end motors to produce up to 730 peak horsepower.

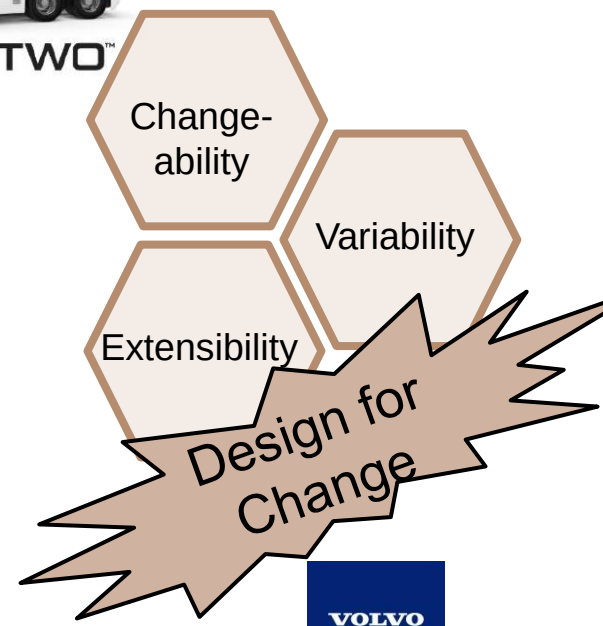
NIKOLA: Fully-electric and hydrogen fuel cells for semi-trailers.

GM Shows Off Autonomous Cargo Hauling Concept Vehicle



- AC 3 phases Permanent magnet, 192 Kw
- Different ratio for axles

Einride uses e-moss NL for the chassis/electric driveline



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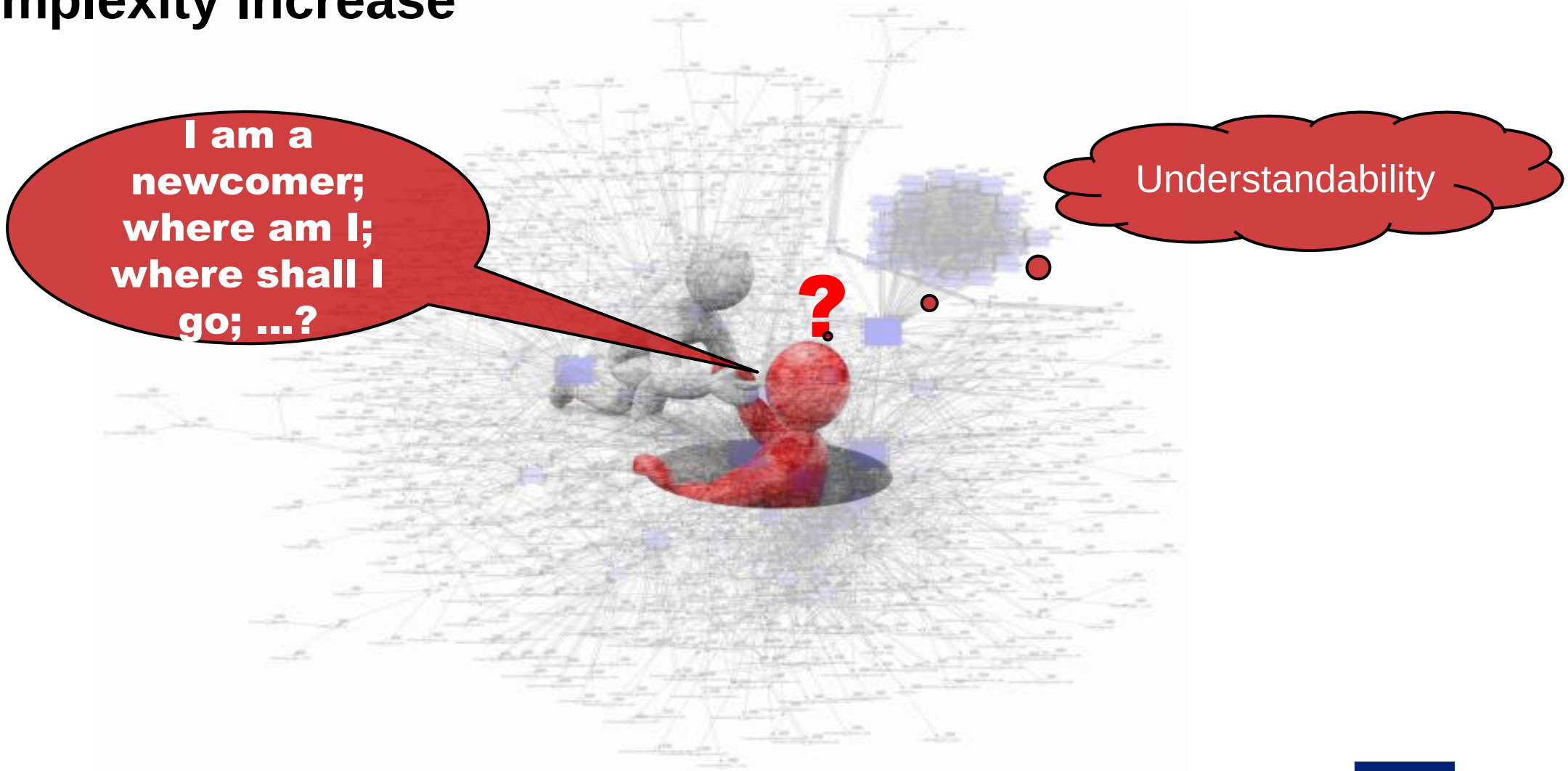
Complexity Increase



Economy of Scale – Reusability & Variability (General)

Product Line Engineering
&
Product Line Architecture /
Reference Architecture

There are many things that are common but also a lot of variances!

Economy of Scale – Reusability & Variability

TARGETS

Transportation Operation Business

- Goods Handling
- People Handling
- Construction Handling

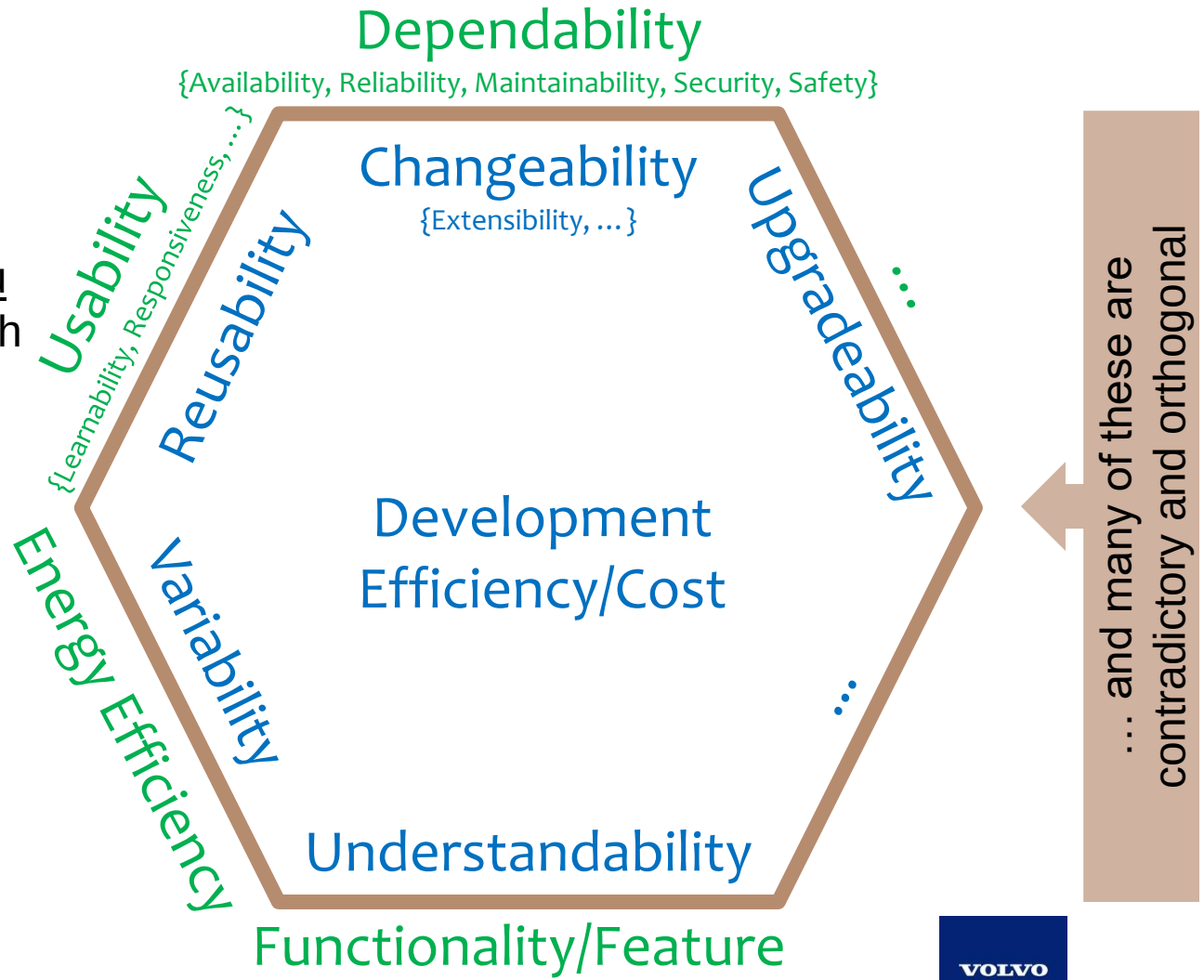
Concern: ... continuation as before is that an option?

... at least not in an ad hoc fashion, feature by feature!

... we need to establish software-centric system thinking!

Summary of key properties

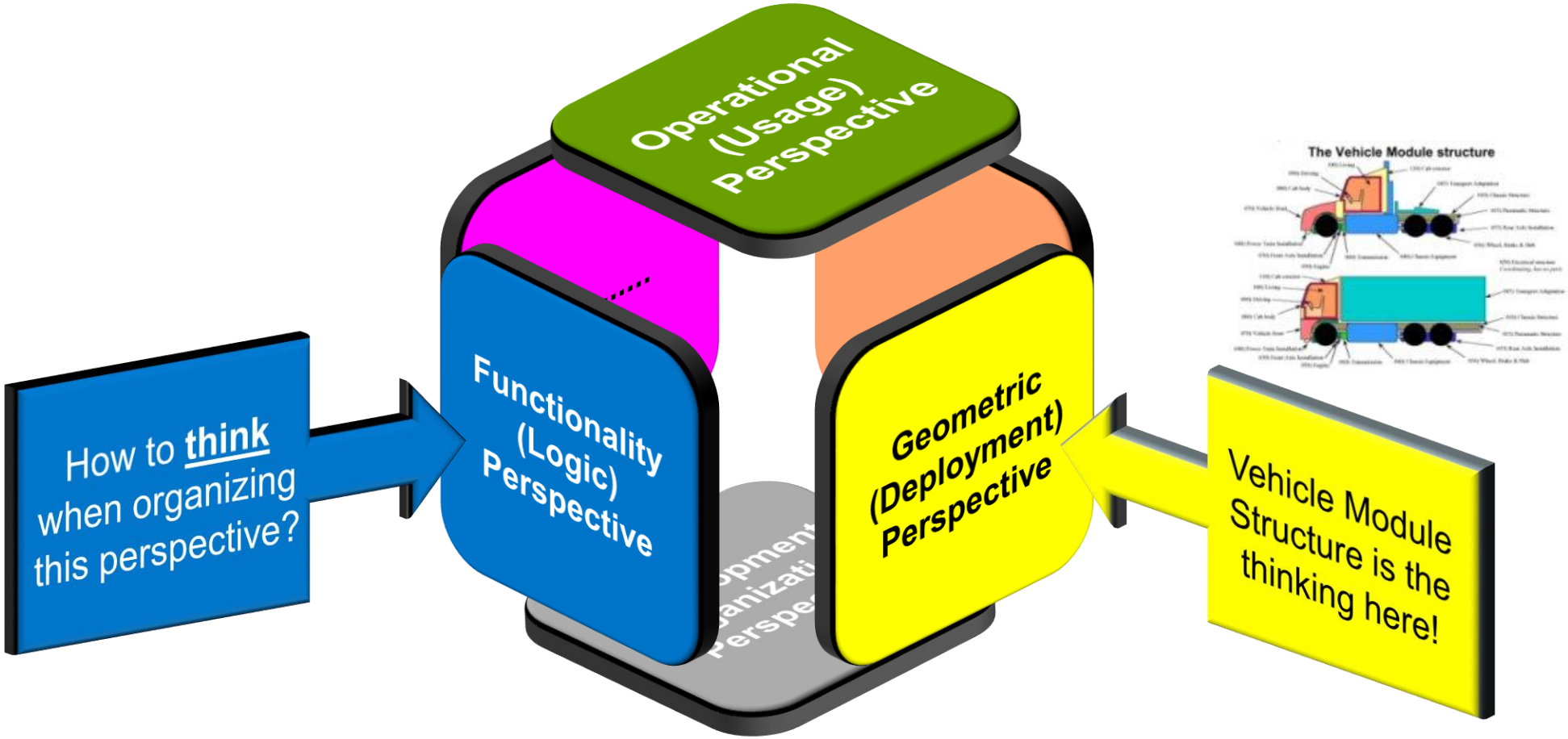
- Architecture is not just done for fun but <u>you want to achieve something</u> specifically such as:
  - …
- We talk about **architectural concerns** (quality attributes or –ilities)!



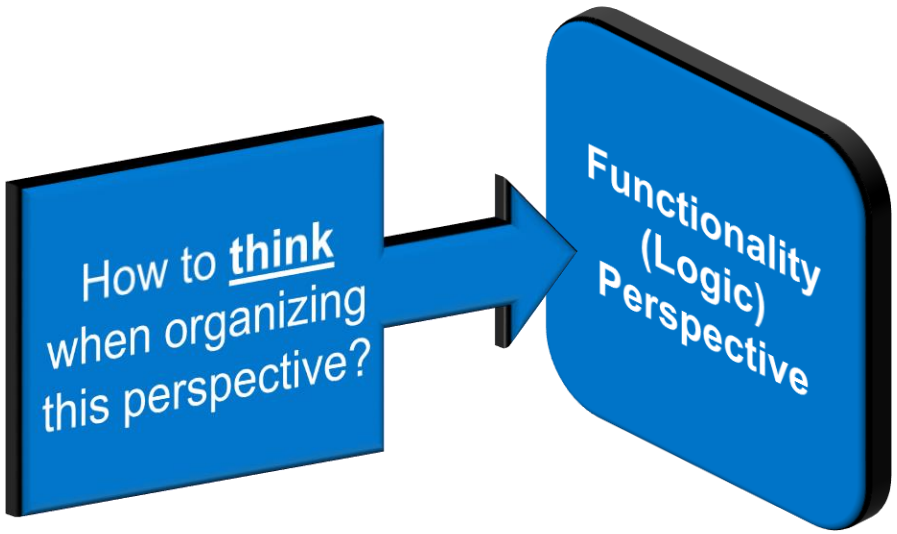
Architecture Thinking

2021-03-01

Functionality (Logic) Viewpoint Introduction ...



Functionality (Logic) Viewpoint Introduction ...



Going from a human performing monitoring & control to ...

Functionality Perspective

SAE LEVEL -1?

Monitor movement with eyes, ears and dangerous situations

Control movement by moving/rotating the handle

… …

«Source System»
Physical Perimeter System

«Functionality System»
Cab Tilting Force Generation

End Position Dection

«Functionality System»
…

«Source System»
Energy Supply & Distribution System

«FS» … «FS» … «FS» …

«Source System»
Torque Supply & Distribution System

«FS» … «FS» …

You can take these modules of functionality and deploy them differently geometrically

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... having a Vehicle Monitoring & Control System

Functionality Perspective

«Source System»

Vehicle Monitoring & Control System

Monitor movement through software (& electroincs)

Control movement through software (& electroincs)

SAE LEVEL 1-5

… …

«Source System»

Physical Perimeter System

The flag/bell is here replaced with a sensor switch.

«Functionality System»

Cabtilting Force Generation

Pump Operation Switch

On Tension Detection

Oil Pressure Detection

End Position Dection

«Functionality System»

…

«Source System»

Energy Supply & Distribution System

«FS» 24V Supply & Distr. System

«FS» …

«FS» …

«Source System»

Torque Supply & Distribution System

«FS» …

«FS» …

Actuator

Sensor

You can take these modules of functionality and deploy them differently geometrically

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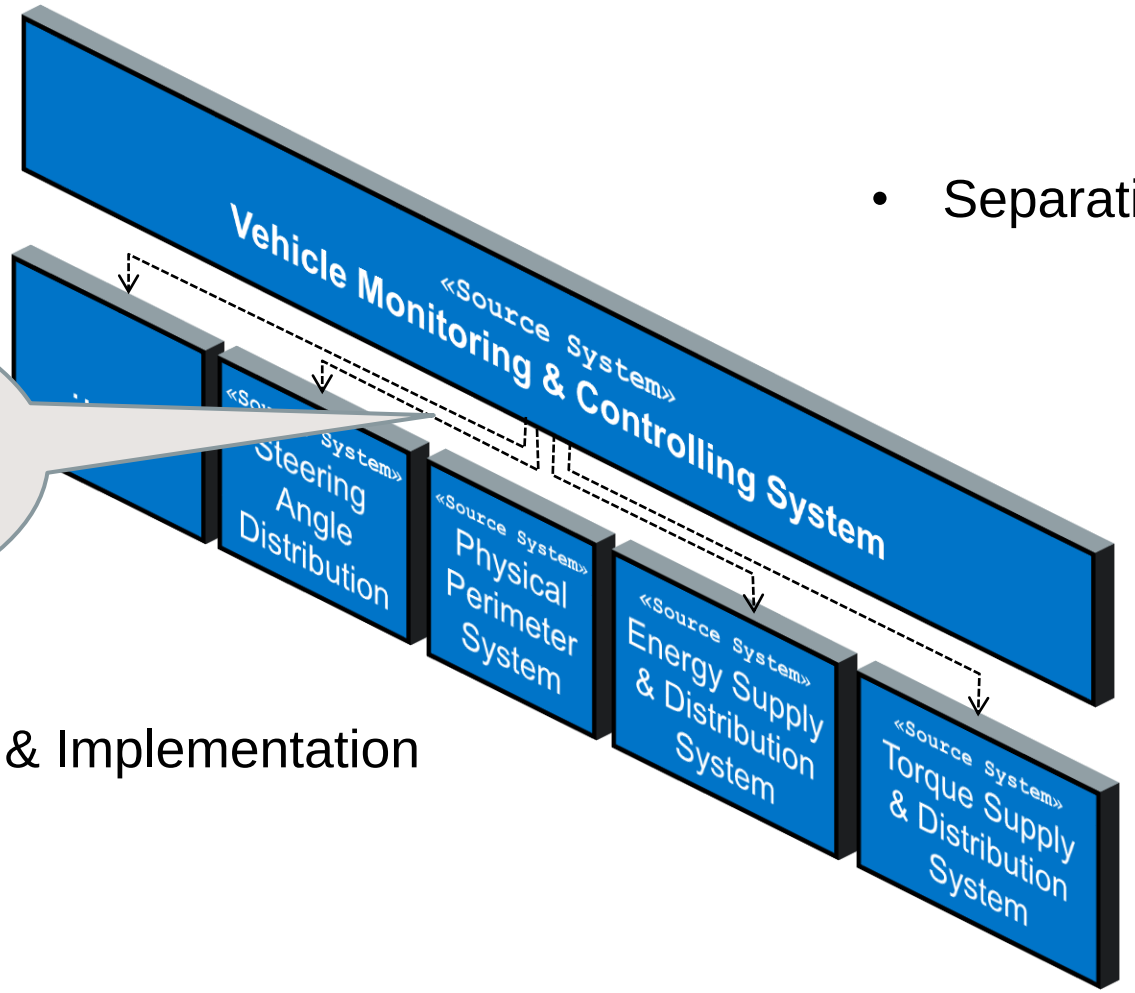
Vehicle Monitoring & Controlling System

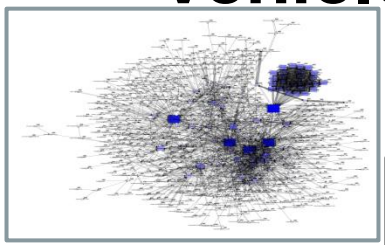
single vehicle focus

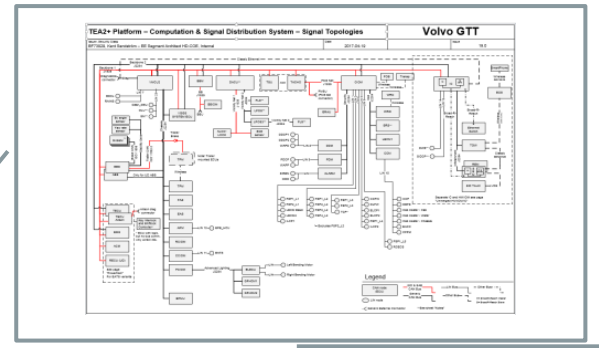


Although ”separtated” things in a large system can never be compleltey separated but there are dependencies

- Separation of Concern
- Separation of Policy & Implementation

Vehicle Monitoring & Controlling System





Computation & Signal Distribution System

Basic Support Services/Utilities

Vehicle Application System

...

Physical Perimeter System

Energy Supply & Distribution System

Torque Supply & Distribution System

Electricity Supply, Storage & Distr. System

Pneumatic Air Supply, Storage & Distr. Sys.

...

Door

Air Tank

Battery

Wheel

Differntial

Friction Brake

Ethernet Transceiver

CAN Transceiver

A/D Converter

Digital I/O Driver

Temperature Sensor

The main reasons:

1. Different nature and concerns
2. Differnt life cycles
3. Differnt kinds of complexities

Zooming in at VAS: Basic Layering

Enables an hierarchcial control design style

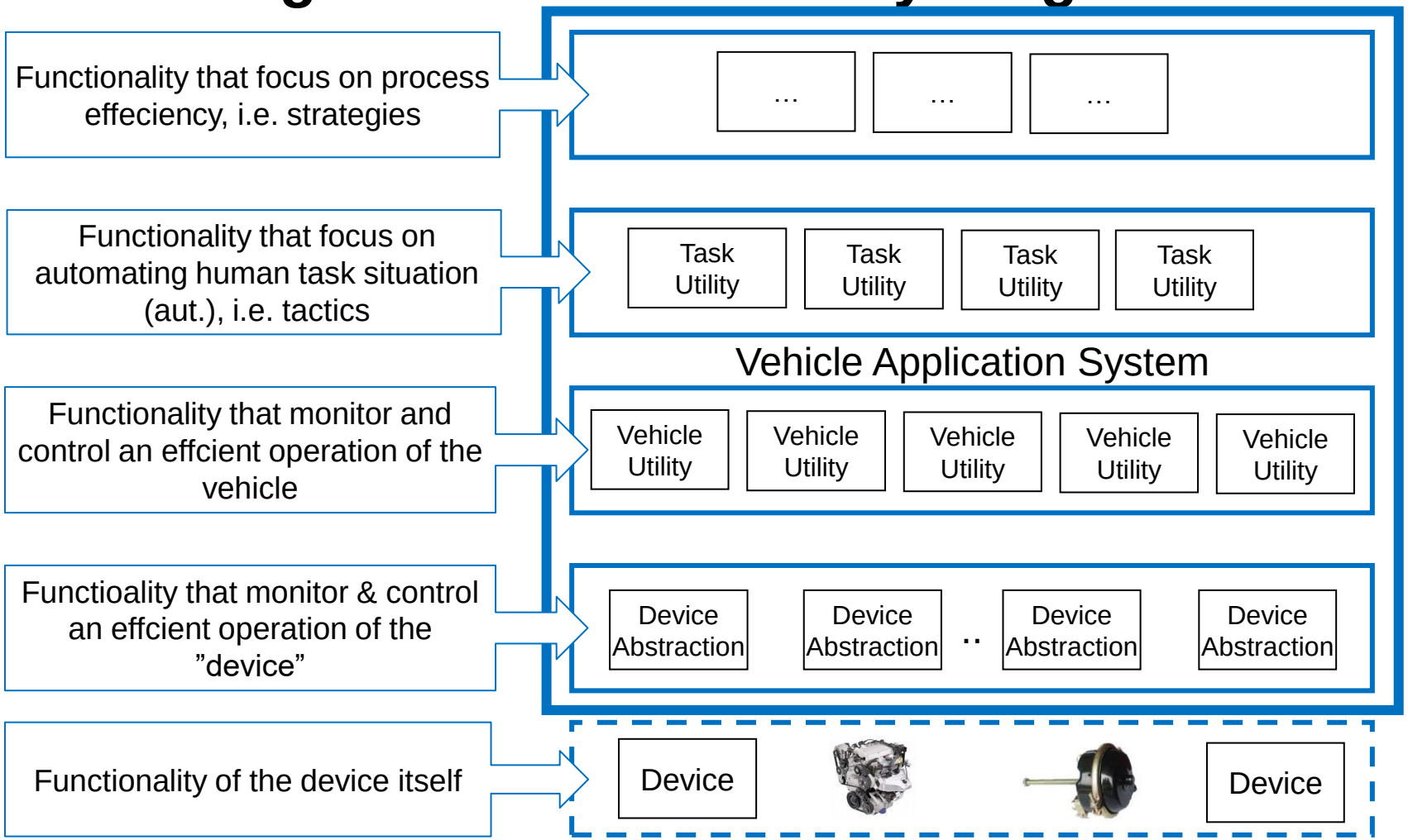
Functionality that focus on process effeciency, i.e. strategies

Functionality that focus on automating human task situation (aut.), i.e. tactics

Functionality that monitor and control an effcient operation of the vehicle

Functioality that monitor & control an effcient operation of the ”device”

Functionality of the device itself



different kinds/levels of functionality

Transport Operation Strategies Layer

Task Situation Tactic Layer

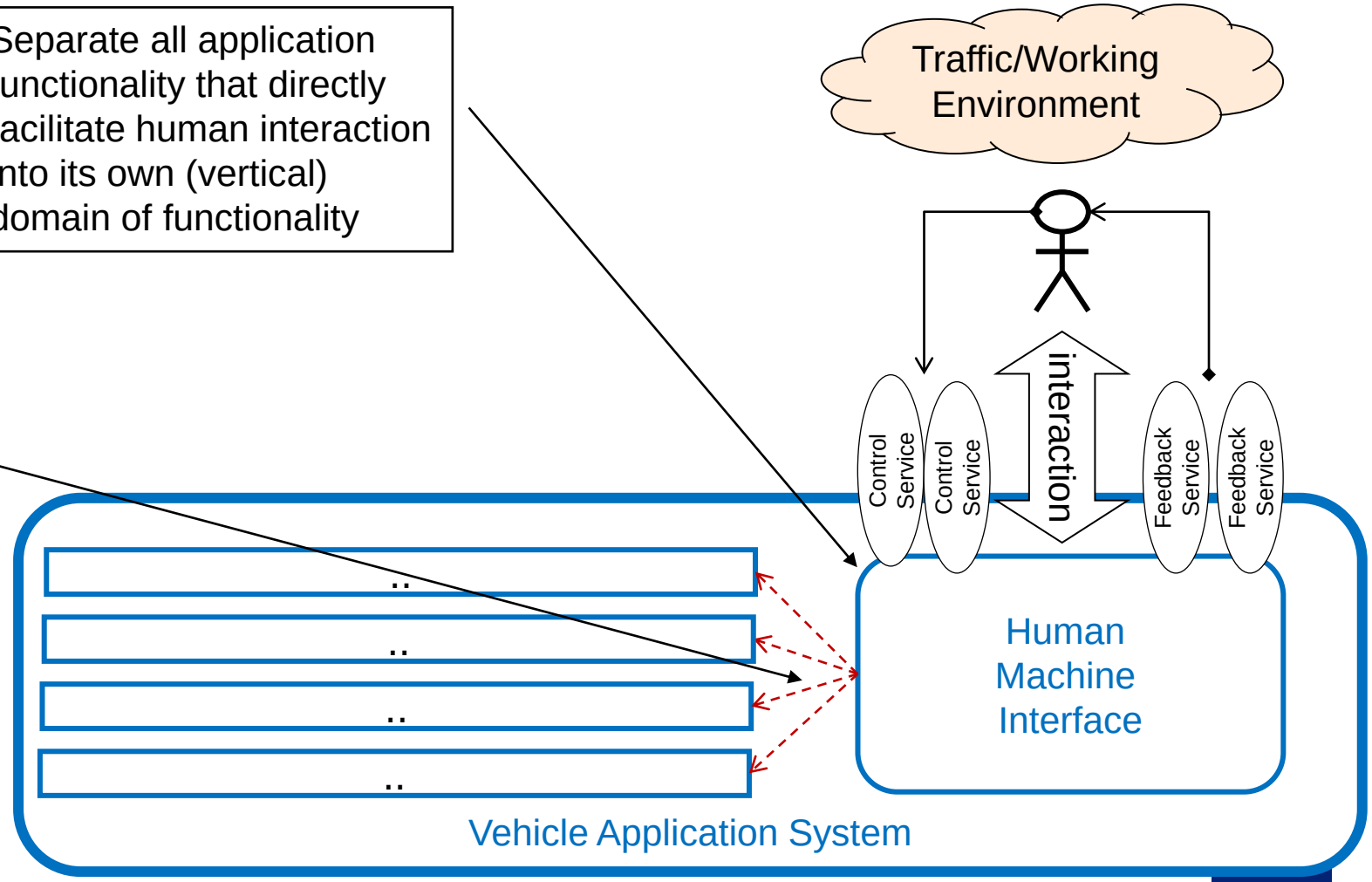
Vehicle Utility Layer

Device Abstraction Layer

User interaction is a concern itself

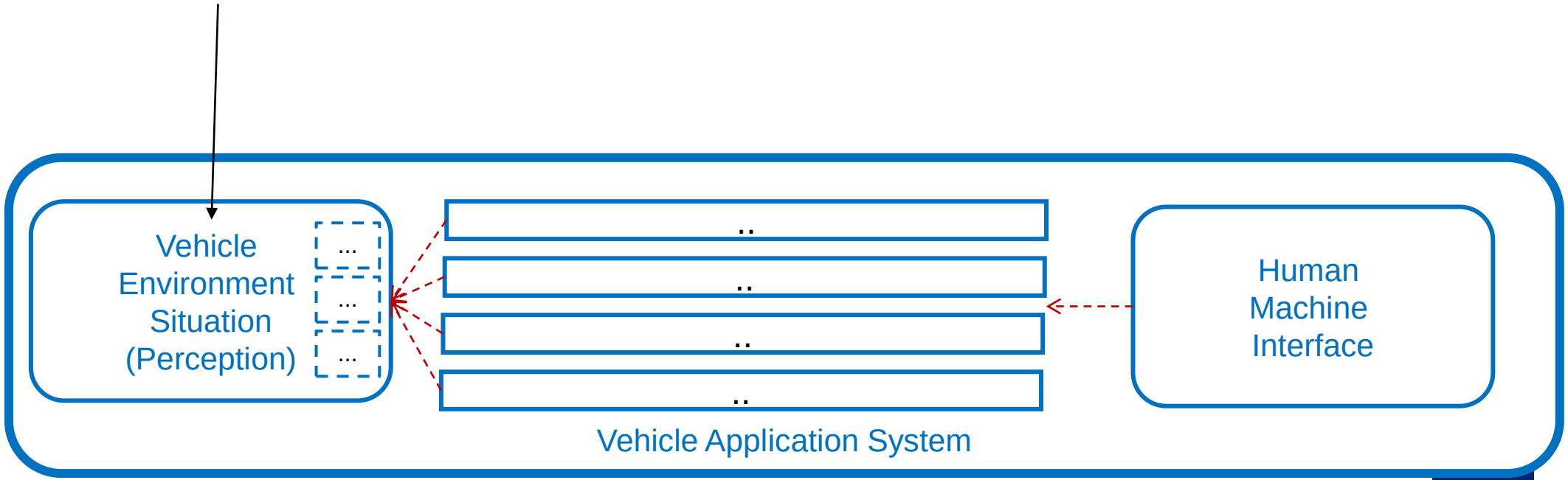
Separate all application functionality that directly facilitate human interaction into its own (vertical) domain of functionality

The necessary Human Machine Interface depends on the design of the system core functionality not the oppsite direction!

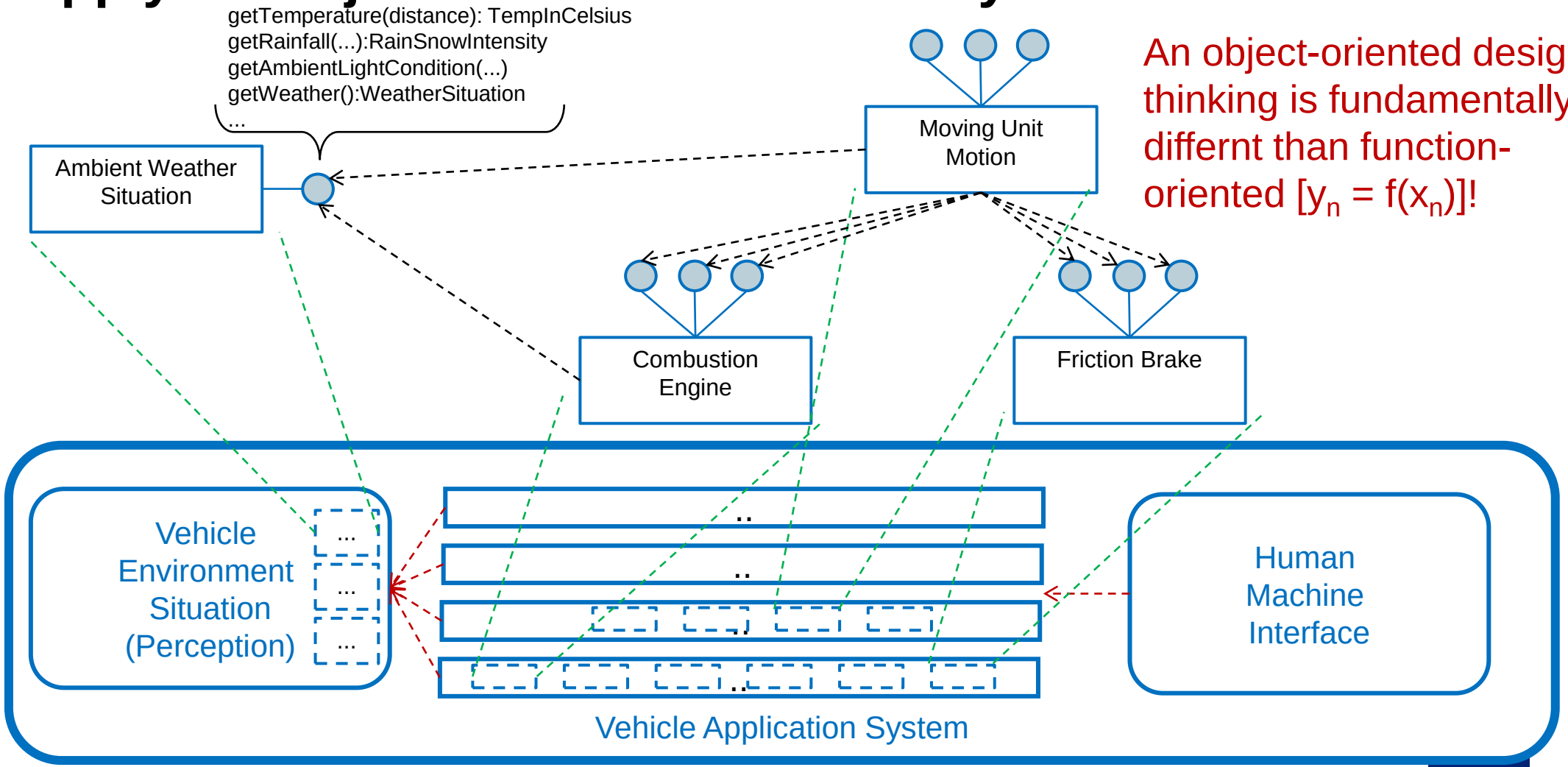


Replacing human “eyes” - Ego Vehicle’s Environment

Separate application functionality directly in place to facilitate an awareness of the ego vehicle's environmental situation (model of the environment) into its own (vertical) domain of functionality



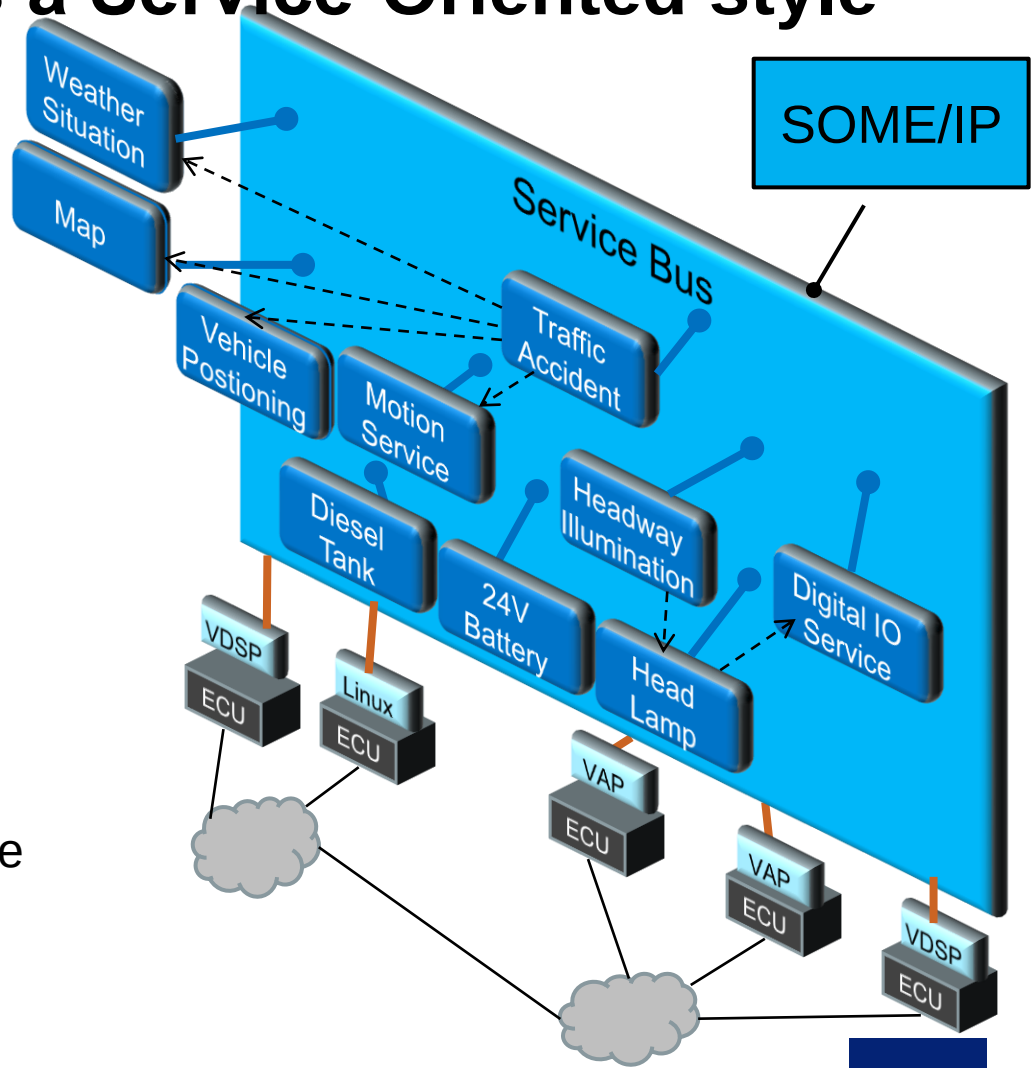
+ apply an Object-/Service-Oriented style



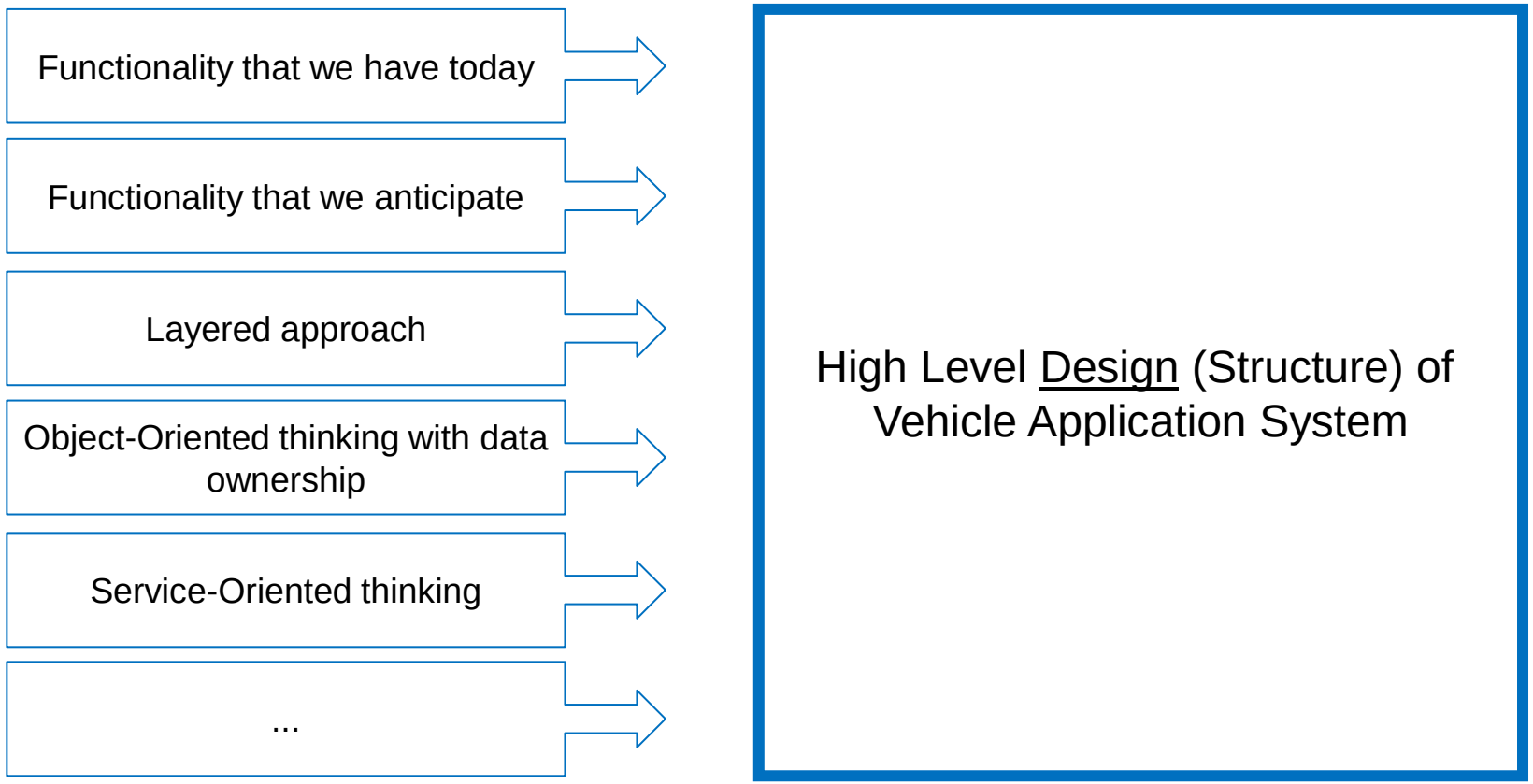
An object-oriented design thinking is fundamentally differnt than function-oriented [$y_n = f(x_n)$]!

… next step is to move towards a Service-Oriented style

- Basically it is about distributed object-oriented applications running in hetrogenous operating system (platforms) providing their services via some kind of broker mechanism, called a Service Bus.
  - Services are expected to be platform independent and able to be called in a generic way not dependent upon a particular programming language.
- Emphasis is on creating components called services, which are small, discrete units of software that provide a specific functionality and can be reused in every application.



Converting Architecture Principles into a Design



«Source System»
Vehicle Fleet Monitoring & Control System

«Functionality System»
Vehicle Application System

Network Configuration Util.

Vehicle Service/Information Access Utilities

Vehicle Environment Situation

Transportation Maintenance (Strategies)

Transportation Planning (Strategies)

Transportation Piloting (Strategies)

Software Installation (Reparing)

Diagnosing

Traffic Situation Mgmt. Tactics

Payload Situation Mgmt. Tactics

Living Situation MgmtTactics

Vehicle Operation & Health Status Utilities

Vehicle Motion & Power Mgmt Utilities

Vehicle Application Support Utilities

Visibility& Conspicuity Utilities

Human Body Protection Utilities

Vehicle Perimeter Utitlites

Compartment Convenience Utilities

Entertainment Utilities

Vehicle User Utilities

User Communication Utilities

Energy Supply & Distri. Devices

Exhaust Distri. Devices

Steering Devices

Torque Supply & Distr. Devices

Suspension Devices

Wheel & Wheel Axle Devices

Axle Lift Devices

Vehicle Adaptation Devices

Body Work Devices

Exterior Lamp Devices

Exterior Sound Devices

Wash & Wipe Devices

Mirror Devices

Restraint Devices

Vehicle Perimeter Devices

Compartment Convenience Devices

Data (Storage) Devices

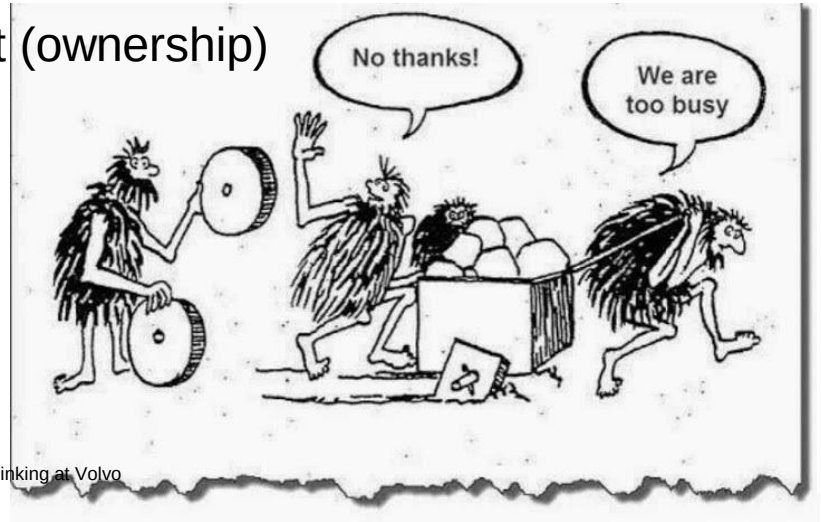
Human Machine Interface

«Functionality System»
Basic Support Services/Utilities

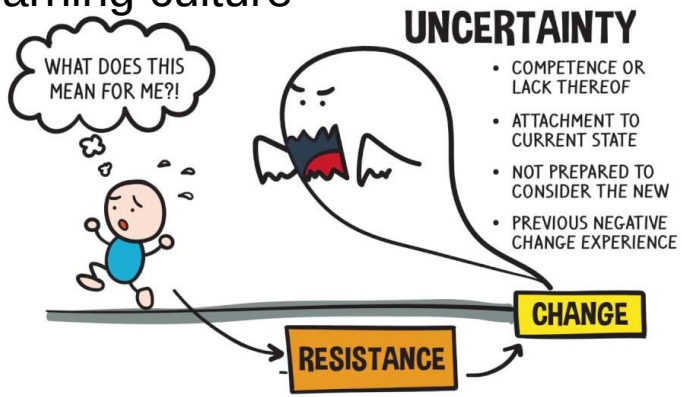
«Functionality System»
Computation & Signal Distribution

Resistance to Architecture Change (Volvo)

- The cost of making architecture changes
  - Maintaining an old product line while developing a new one in parallel
  - Future is always downprioritized over immediate deliveries
    - Organization waited too long to make architecture changes
- Organization impact (ownership)
- ... ...



- Sounds good as long it doesn't impact me at personal level
  - Understanding
  - Competence / Education, e.g. going from the mindset in Simulink to an object-/service-oriented design style is really challenging.
  - Company learning culture




THANK
YOU!

Discussion & Questions

- Architecture is very much about how you think when you design, system, software, eletronics, ...
- So, how can you change and impact an exisiting ”thought style”?
- What is your own ”thought style”?