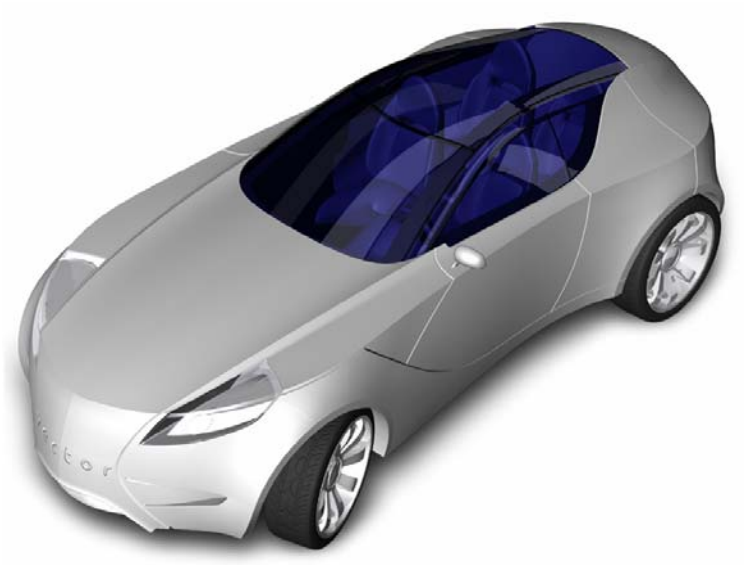

MICROSAR.blue Saves CO_2

Are There Limits of Standard Software's Benefit

Agenda

> **Motivation**

Introduction

Possibilities

Summary

Motivation

Reduce CO_2 emission

- The efficiency of engines, generators,… increased
- Energy demand for the ECUs is increasing as there are more and more µControllers in the car to provide more safety, comfort, …
- The cars will provide more and more entertainment.
- The driver will spent more time in the car (DVD-Player, E-Mails,…).

→ Let's have a deeper look into the energy demand of the ECUs and the ways how to optimize this

Agenda

Motivation

> **Introduction**

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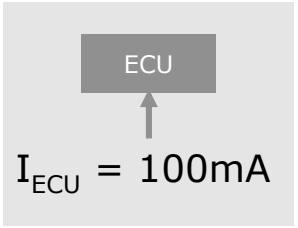
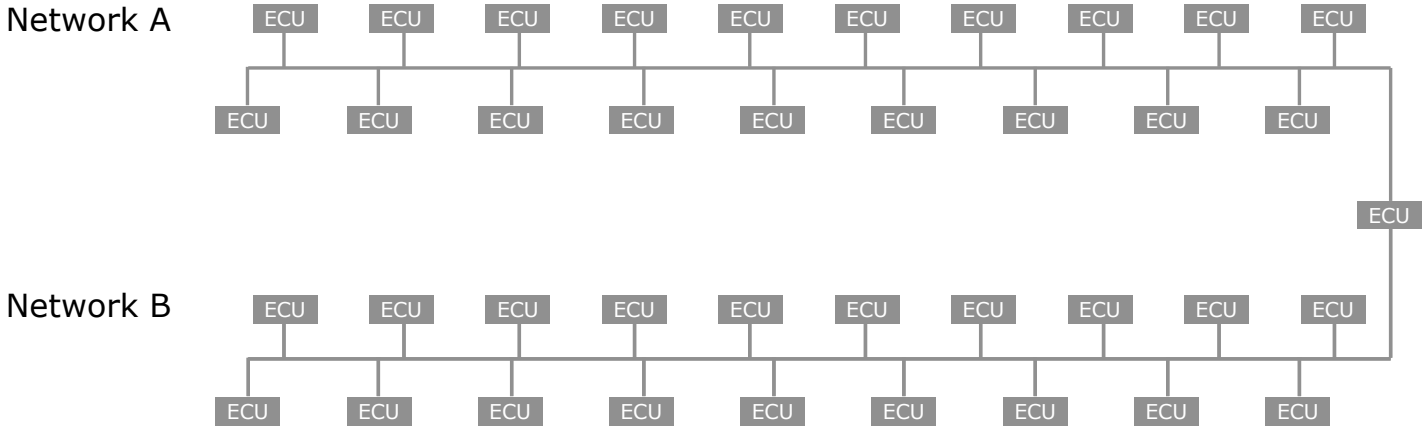
Summary

Sample network used for calculation

- Example network to calculate the estimated effects
  - **2** different networks
  - **20** ECU on each network
  - **100mA** current drain per µController





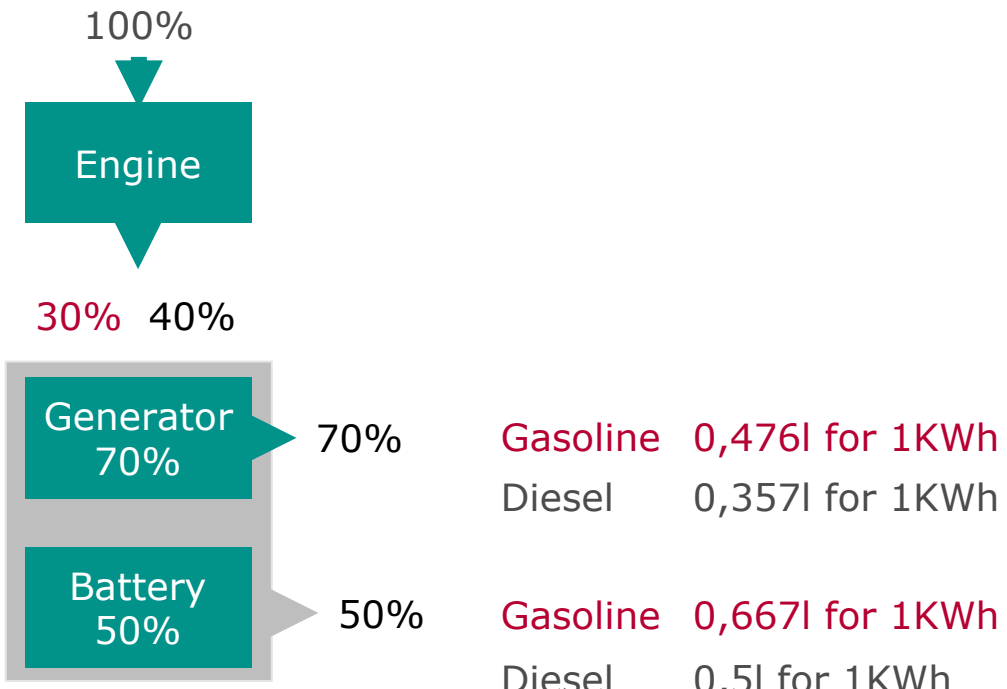
Sample network used for calculation

Estimated need of fuel for 1kWh energy

- 0,1l Fuel ≈ 1kWh

Assumed CO_2 equivalent:

2.4kg CO_2/l



Assumed use case for Cars and Trucks

- CAR
  - Mileage per year: 20000 km
  - Average speed: 50 km/h → **400h** per year the car is driving
  - 3 % of the time, the ignition is on with engine stopped → **12h** networks are powered with engine stopped

- TRUCK
  - Used during 200 days per year
  - 9h steering time per day → **1800h** per year
  - 2h rest time with ignition on and engine stopped per day

    → **400h** networks are powered with engine stopped

Assumed use case for Cars and Trucks

- CAR
  - Running engine
    - 400h * 40ECUs * 100mA * 12V * 0, 476l/kWh = **9,14l** per year and car
  - Engine stopped
    - 12h * 40ECUs * 100mA * 12V * 0,667l/kWh = **0,38l** per year and car
- TRUCK
  - Running engine
    - 1800h * 40ECUs * 100mA * 12V * 0, 357l/kWh = **30,84l** per year and truck
  - Engine stopped
    - 400h * 40ECUs * 100mA * 12V * 0,5l/kWh = **9,6l** per year and truck

Agenda

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> **Possibilities**

Summary

Possibilities

What are the potentials

1. Reducing power consumption of the ECU by downsizing the CPU

2. Switch off unused ECUs

Possibilities

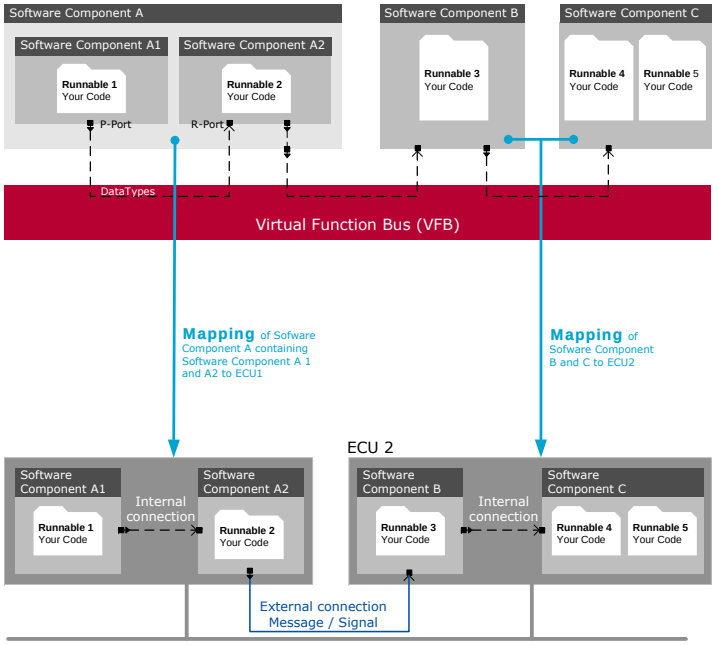
Downsizing the CPU

- Optimized code
- Minimized runtime

→ Downsize of CPU possible
→ Reduced clock frequency possible

- Intelligent mapping of SWC to ECUs
- Optimized usage of clock frequency

→ Downsize of CPU possible
→ Reduce the number of ECUs



Optimization of code to reduce runtime

1

CAR and TRUCK

Approximately reduction of power consumption per **MHz** of clock frequency: **1mA**

- Reducing the clock by 1MHz per ECU in the sample network safes

  400h*12V*40*1mA*0.476l/kWh + 12h*12V*40*1mA*0,667l/kWh= **0,095l** per year and car

  1800h*12V*40*1mA*0.357l/kWh + 400h*12V*40*1mA*0.5l/kWh= **0,40l** per year and truck

1 million new cars per year	300 thousand new trucks per year
0,095l * 1.000.000 = **95.000l** per year	0,40l * 300.000 = **120.000**l per year

vector

Possibilities

What are the potentials

1. Reducing power consumption of the ECU by downsizing the CPU

2. Switch off unused ECUs

Vehicle mode management (VMM) concept

What is Vehicle Mode Management?

- The VMM concept allows distribution of configurable vehicle modes within the vehicle.
  (WP 1.1.2 for AUTOSAR Release 4.0)
- With the knowledge of vehicle modes, mode specific actions can be performed.

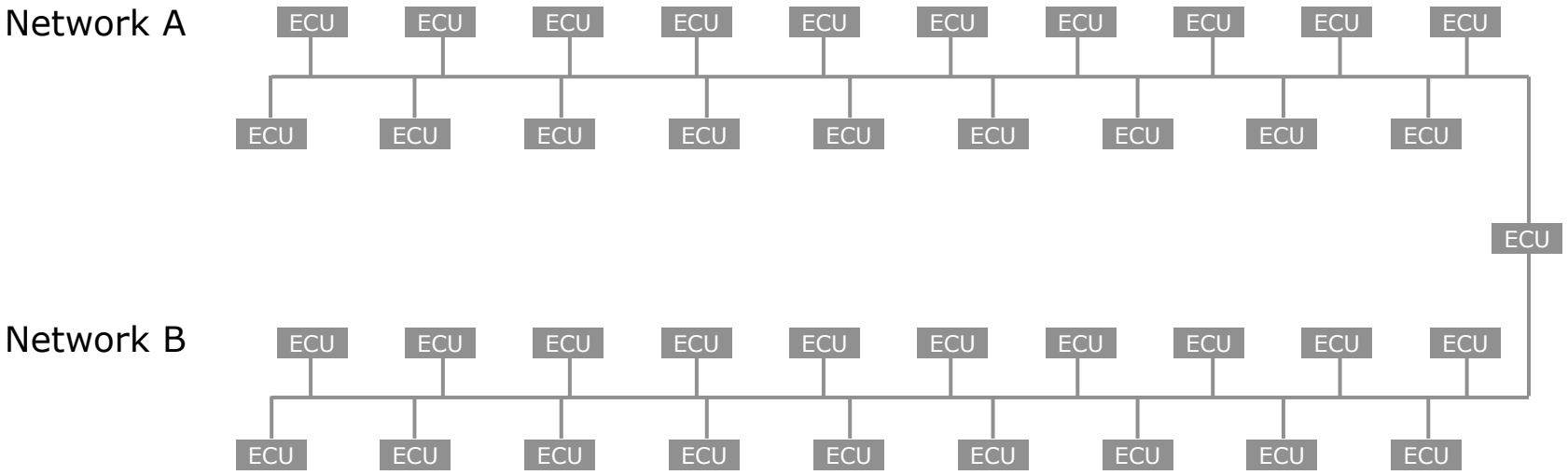
- Distribution of vehicle mode requests to each ECU
- Evaluation of the mode request within each ECU
  - Activate functions based on the requested vehicle mode

Possibilities

2

Switch off unused ECUs

- Mode dependent deactivation of an entire network
- Mode dependent deactivation of ECUs



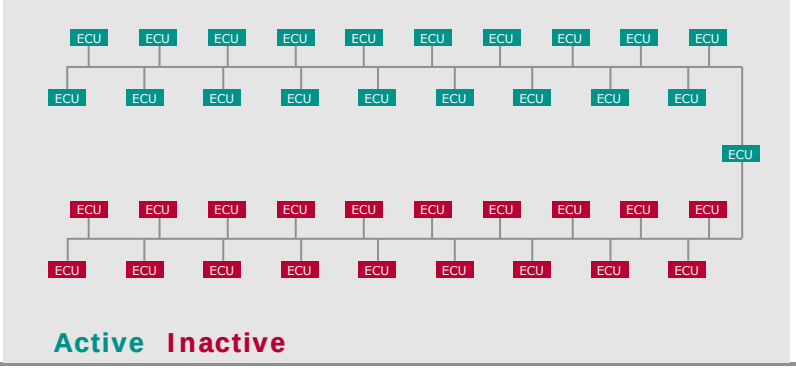
Active Inactive

Mode dependent deactivation of networks

2

CARS and TRUCKS with engine stopped

- Depending on the current vehicle mode, entire networks can be deactivated. For example
  - Unlocking the doors
  - listening to radio or watching video inside the car
- Especially in trucks during the required rest times, multi media equipment like DVD players are used which keep all networks active while the engine is stopped



Mode dependent deactivation of networks

2

CARS and TRUCKS with engine stopped

- Estimated reduction for Car use case if one network is kept unpowered

  12h * 20*100mA * 12V * 0,667l/kWh = **0,19l**
  per year and car

  400h * 20*100mA * 12V * 0,5l/kWh = **4,8l**
  per year and truck

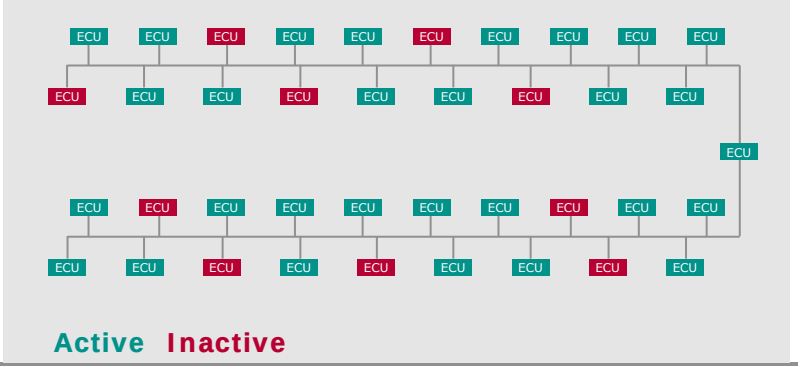
1 million new cars per year	300 thousand new trucks per year
0,19l * 3.000.000 = **190.000l** per year	4,8l * 300.000 = **1.440.000l** per year

Mode dependent deactivation of ECUs

2

CARS and TRUCKS with engine running

- Some ECUs are always activated without any benefit
- Defining ECUs which can be deactivated depending on the vehicle mode
  - Rear trunk, trailer ECU,…



Mode dependent deactivation of ECUs

2

CARS and TRUCKS with engine running

- Assumed number of ECU which can be deactivated during the driving: 10

400h * 10 * 100mA * 12V * 0,476l/kWh = **2,28l**
per year and car

1800h * 10 * 100mA * 12V * 0,357l/kWh = **7,71l**
per year and truck

1 million new cars per year	300 thousand new trucks per year
2.28l * 1.000.000 = **2. 280.000 l** per year	7,71l * 300.000 = **2.313.000 l** per year

Mode dependent deactivation of application parts

Application Parts – PART of OEM and Suppliers

- Deactivation of application parts depending on the vehicle mode
- Switching into power safe mode
- Switching off output stages
- Switch to lower clock frequency
- .
- .

Agenda

Motivation

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> **Summary**

Summary

What's the result?

- Notable effort necessary to define vehicle modes

- The possibility of the Standard Software itself is restricted

	Car (gasoline)			Truck (diesel)		
	Litre / Year	**Litre / 100 Km**	**€ / Year**	**Litre / Year**	**Litre / 100 Km**	**€ / Year**
All ECUs are running	9,52	0,048	14,28	40,44	0,045	55,81
All Concepts realized	2,57	0,013	3,86	12,91	0,014	17,80

1,50€ / litre gasoline 1,38€ / litre diesel

Summary

But…

- The number of vehicles delivers impressing numbers

	1 million Cars			300 000 Trucks		
	[Litre Gasoline]	**CO2 [t]**	**€**	**[Litre Diesel]**	**CO2 [t]**	**€**
All ECUs are running	9.520.000	22.848	14.280.000	12.132.000	29.117	16.742.160
❶ Reduced by 1Mhz per ECU	95.000	228	142.000	120.000	288	1.656.000
❷ One Network is switched off, engine stopped	190.000	456	285.000	1.440.000	3.456	1.987.200
10 ECUs are switched off, engine running	2.280.000	5472	3.420.000	2.313.000	5.551	3.191.940

1,50€ / litre gasoline 1,38€ / litre diesel

Summary

Worldwide 500.000.000 cars

3.078.000 t CO2 / Year

… and further possibilities within your application still open

Thank you for your attention.

For detailed information about Vector
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www.vector-informatik.com

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Additional runtime resources of the VMM

2

Additional Software = additional runtime overhead?

- Does the VMM need more resources as it saves? NO!
  - Looking at the runtime of the evaluation of a vehicle mode request it can‘t be disregarded compared to other functionalities.
  - Looking at the required runtime within an entire operation sequence from starting to drive and stopping again, the fraction of runtime needed for the VMM can be disregarded as it is only executed in case of a mode request