

Transient Co-Simulation of Comprehensive Vehicle Models by Time dependent coupling

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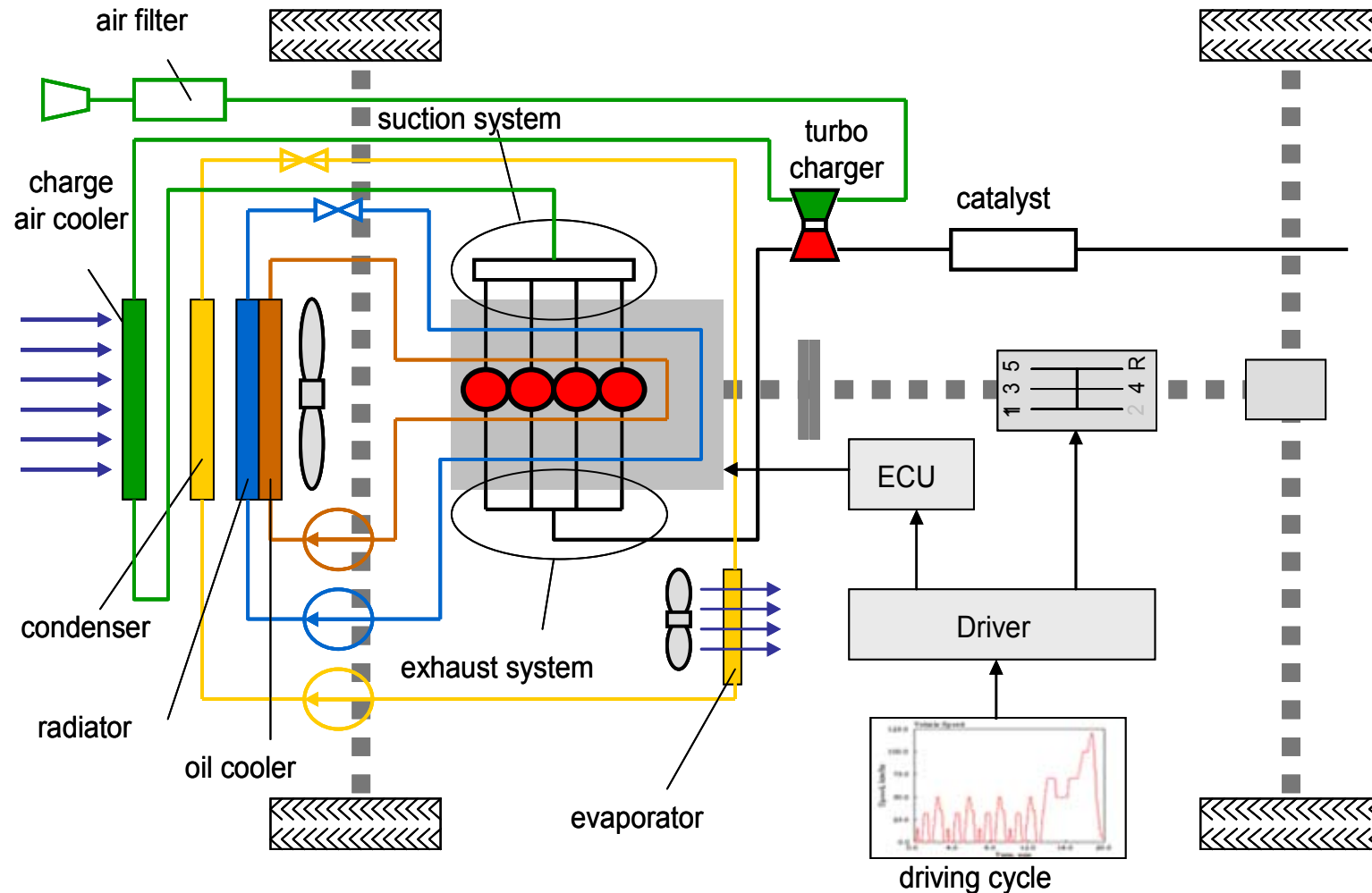
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AGENDA

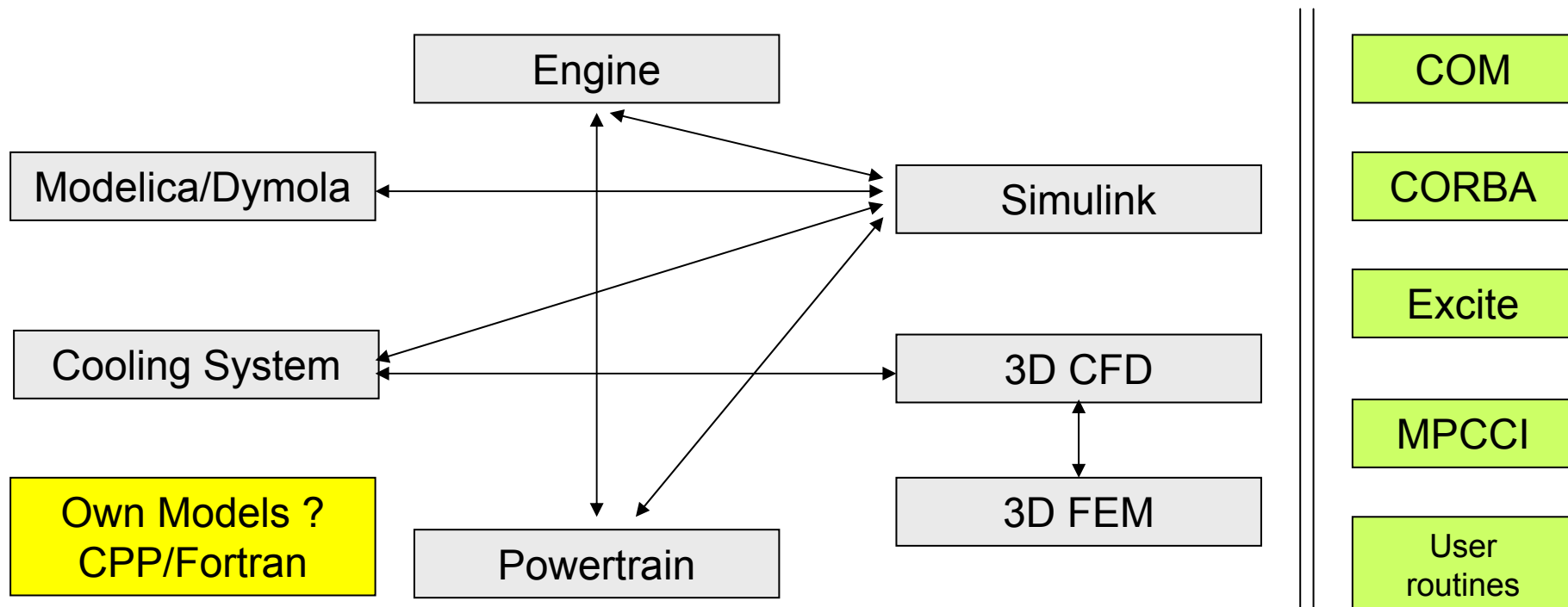
- Motivation – Coupling
- State of Practice
- Coupling Approaches
- Thermal Management System
- Physical Interface
- Integration Platform
- Time Management
- Examples
- Conclusion and Outlook

MOTIVATION

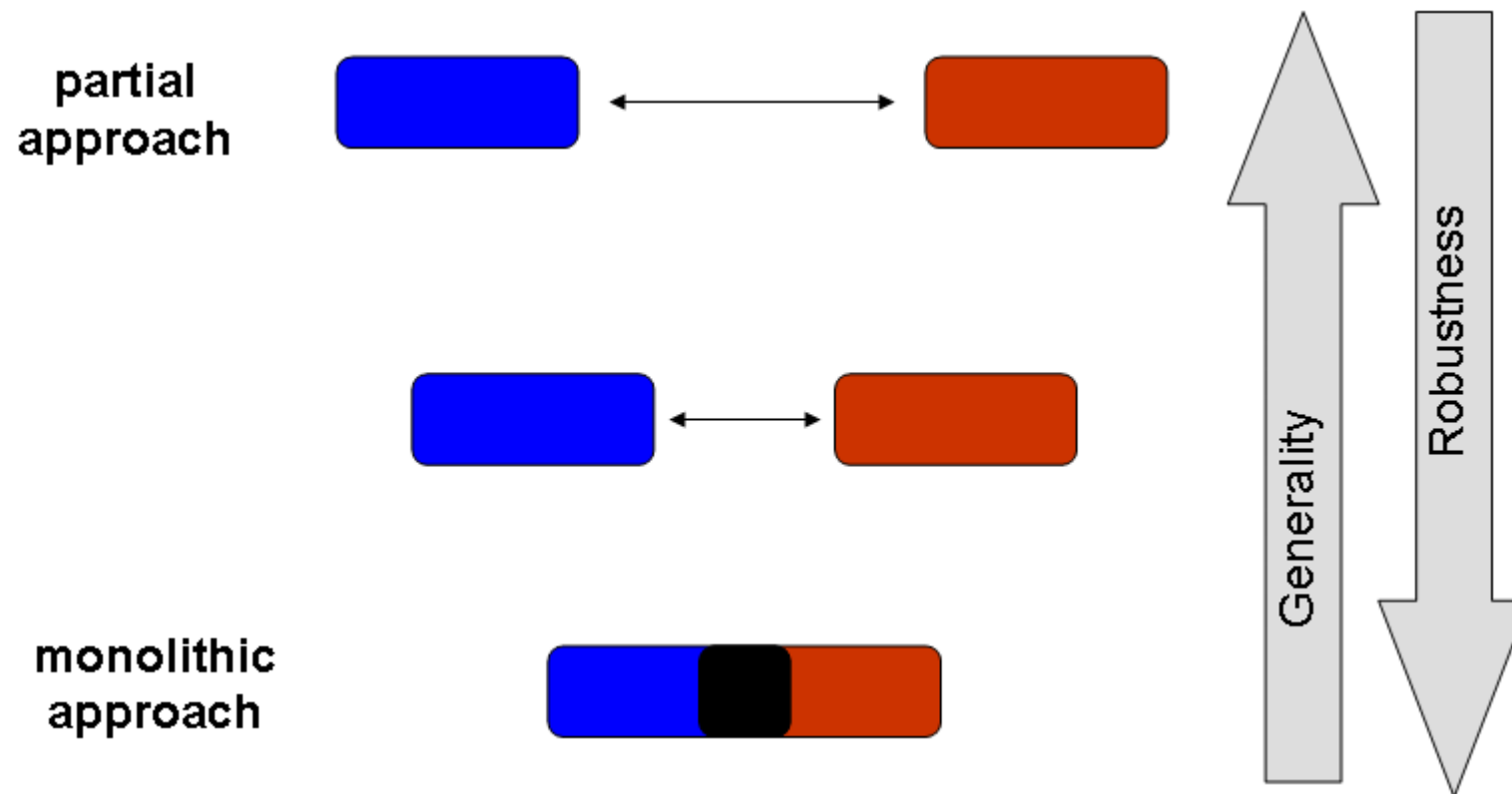


STATE OF Practice

- Fixed Coupled Solutions
- Specialized Coupling Technologies

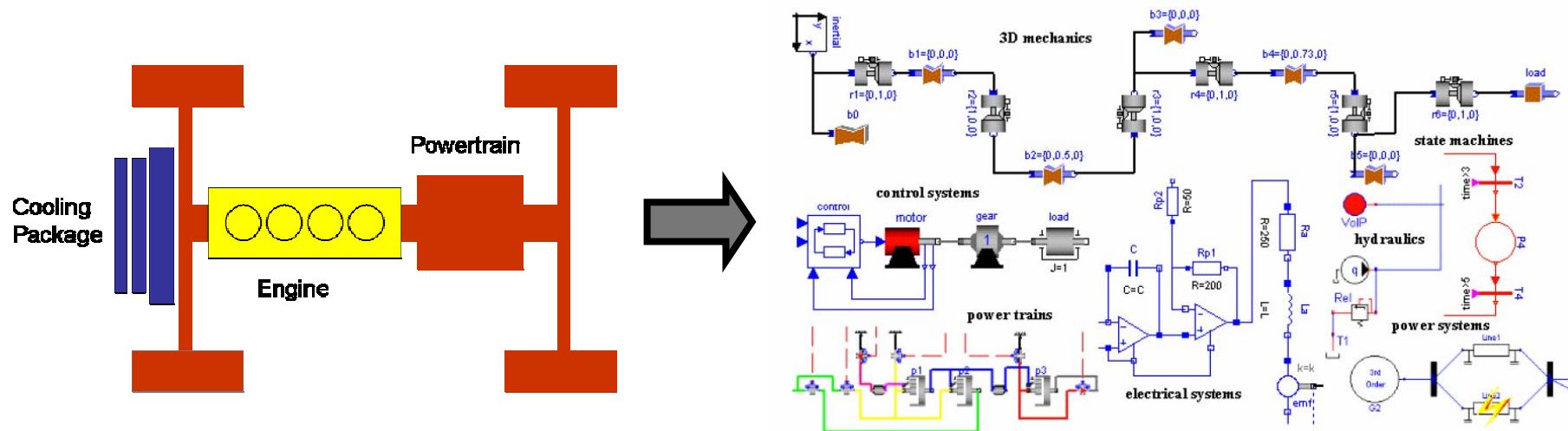


COUPLING APPROACHES



MONOLITHIC APPROACH

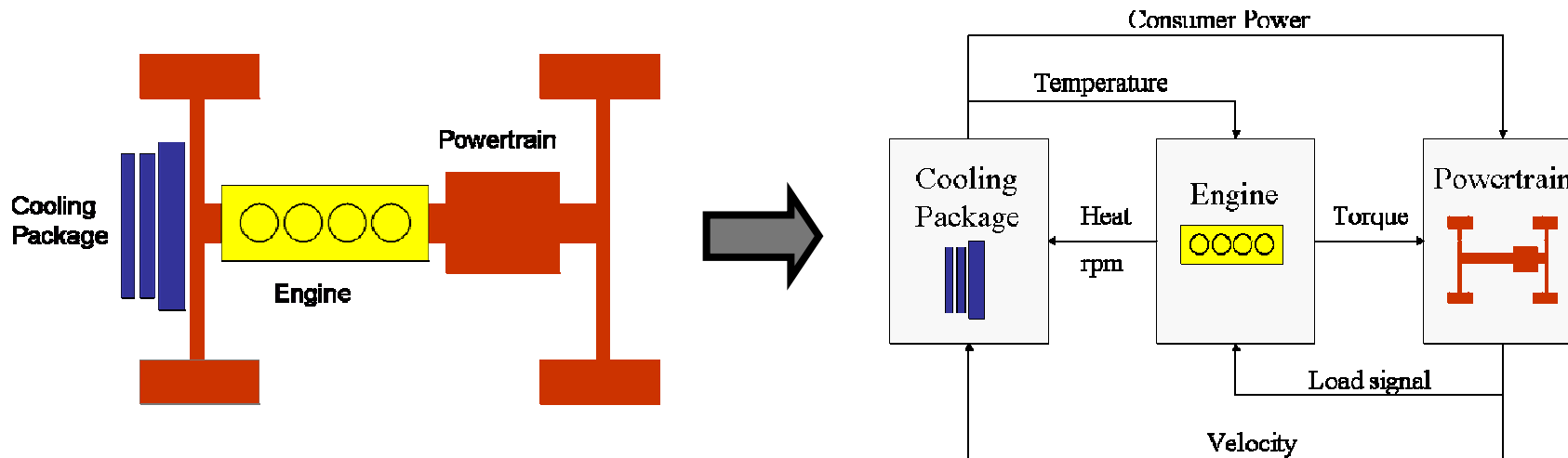
- Different Physics in one Model
- Same Numerical Solver for all Physics
- Strong Coupling between the Models
- New Modeling for existing Models required



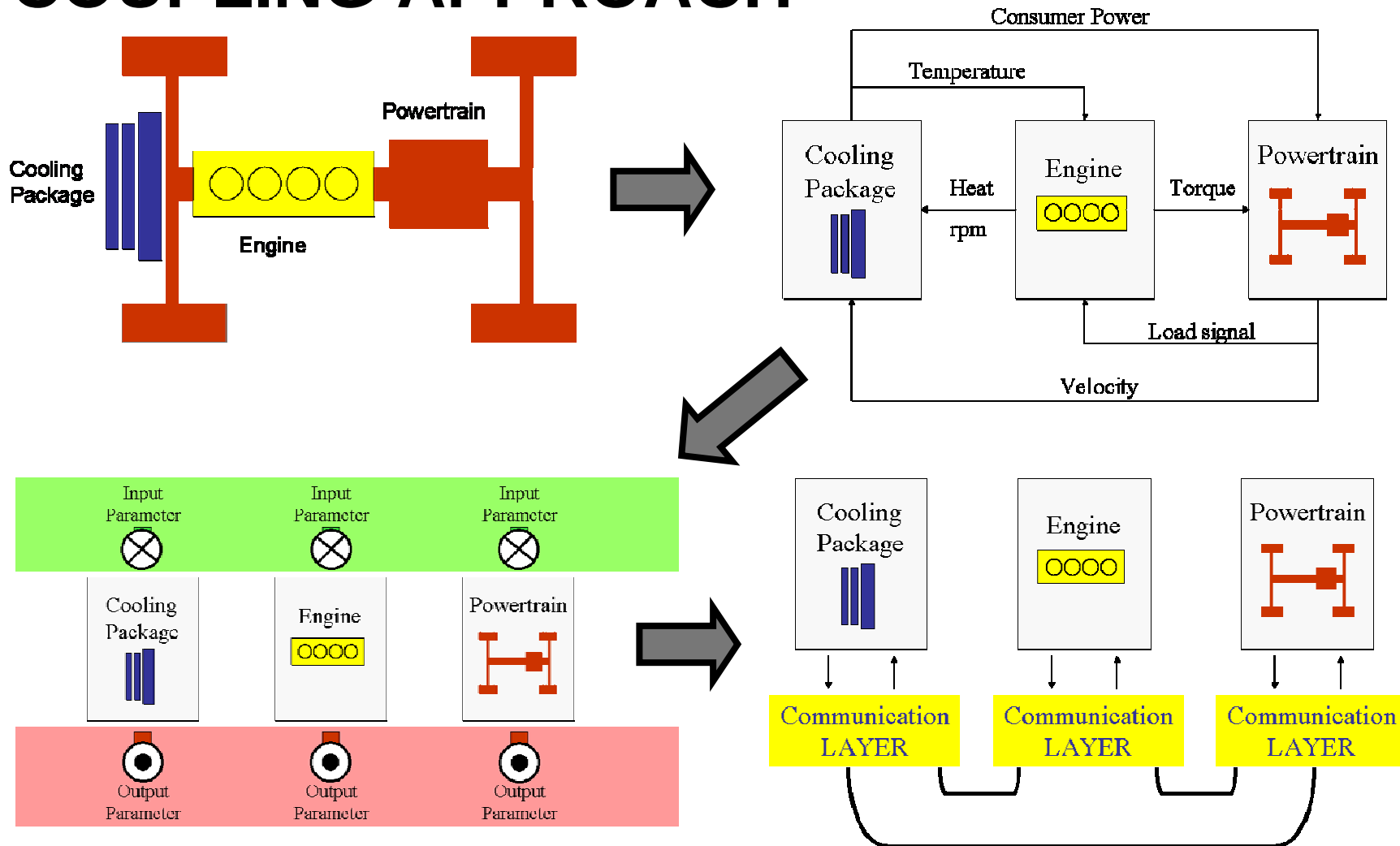
Source: www.modelica.org

PARTIAL APPROACH

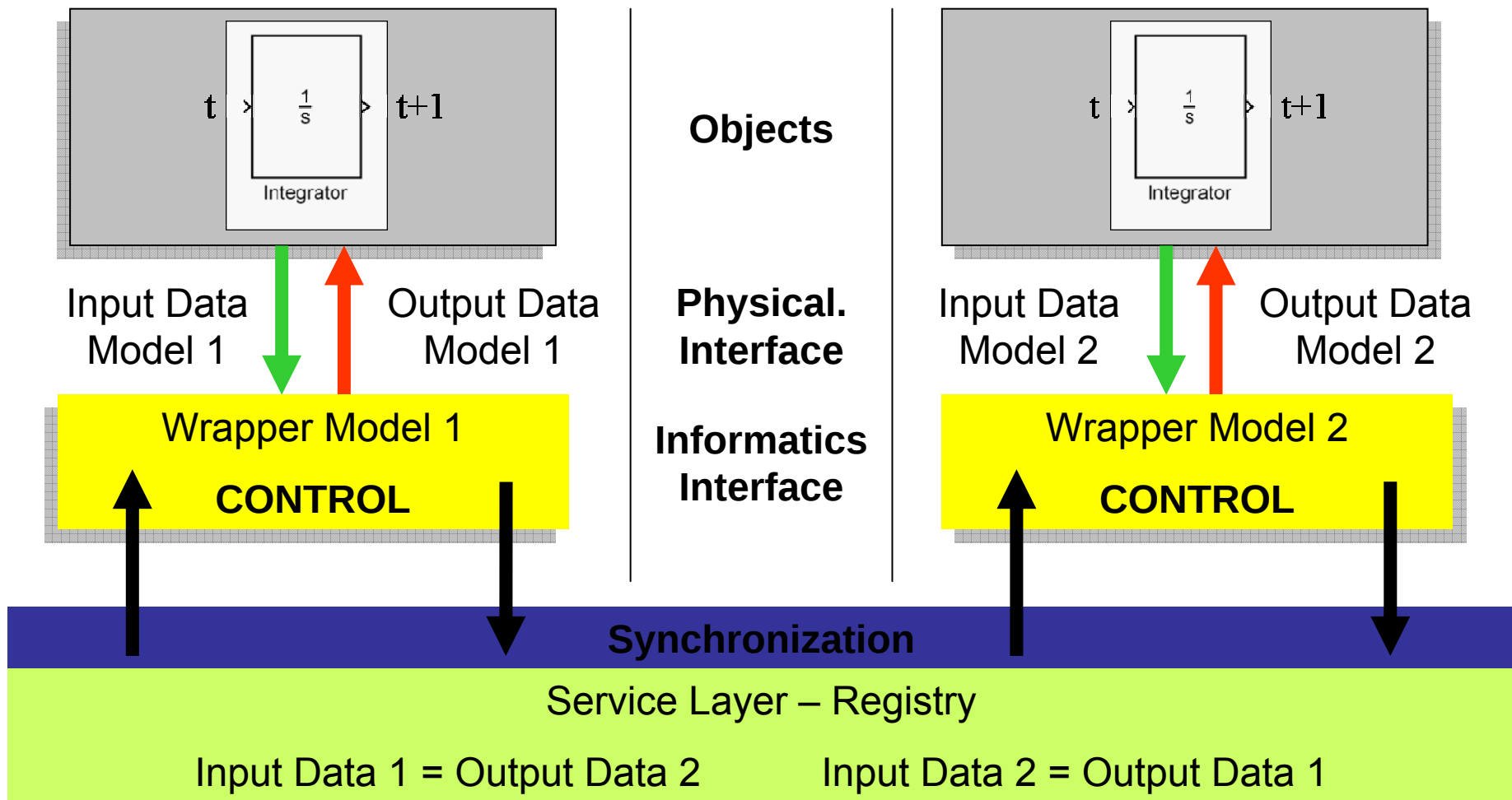
- Commercial Simulation Tools, Existing Models
- Different Numerical Solver for each Physic
- Light Coupling between the Models
- Establish an Coupling Environment



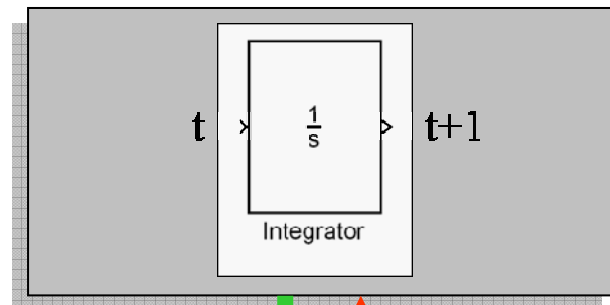
COUPLING APPROACH



COUPLING APPROACH



COUPLING APPROACH



Input Data
Model 1

Output Data
Model 1

```
KULI_COM.initialise()
KULI_COM.ScanCOMInterface{in and out COM parameters are read}
MTS_VAR_DEF{ in and out parameters are published}
MTS_VAR_PUBLISH{ blocking command }
```

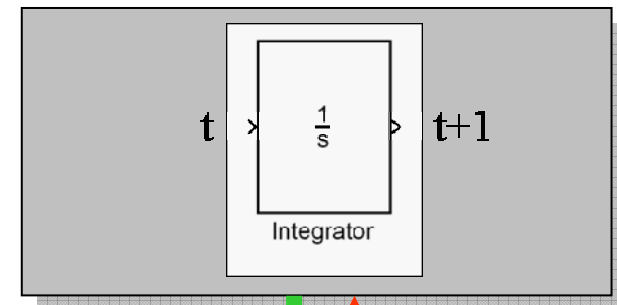
While KULI_COM_NextTimeStep

```
MTS_VAR_GET{ new parameters, time}
KULI_COM.set_values( parameters write to KULI)
    KULI_COM_InnerIteration
KULI_COM.get_values( parameters read from KULI)
MTS_VAR_PUSH{ new parameters, time}
```

```
MTS_VAR_SIM{ new parameters, time}
```

Objects

Physical.
Interface



Input Data
Model 2

Output Data
Model 2

```
CRUISE_DLL.initialise()
CRUISE_DLL.ScanCOMInterface{in and out parameters are read}
MTS_VAR_DEF{ in and out parameters are published}
MTS_VAR_PUBLISH{ blocking command }
```

For CRUISE_DLL_TimeStep

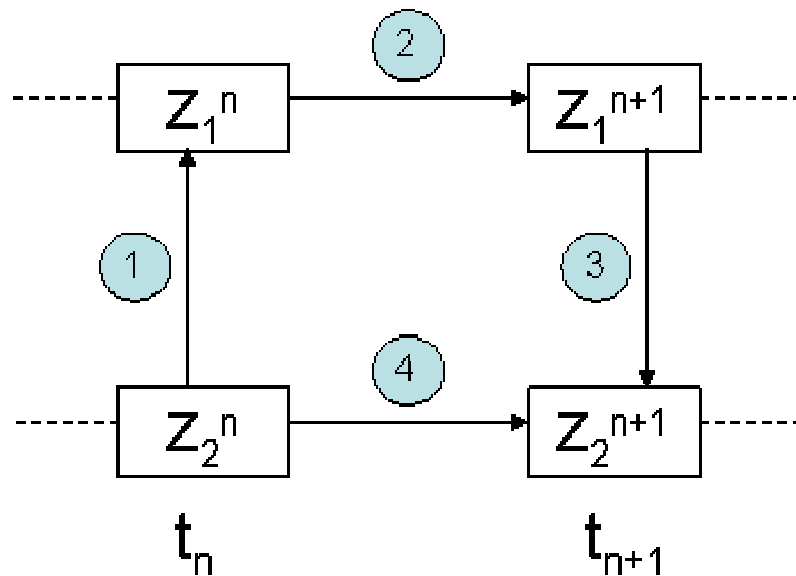
```
MTS_VAR_GET{ new parameters, time}
CRUISE_DLL.set_values( parameters write to KULI)
    CRUISE_DLL_InnerIteration
CRUISE_DLL.get_values( parameters read from KULI)
MTS_VAR_PUSH{ new parameters, time}
```

```
MTS_VAR_SIM{ new parameters, time}
```

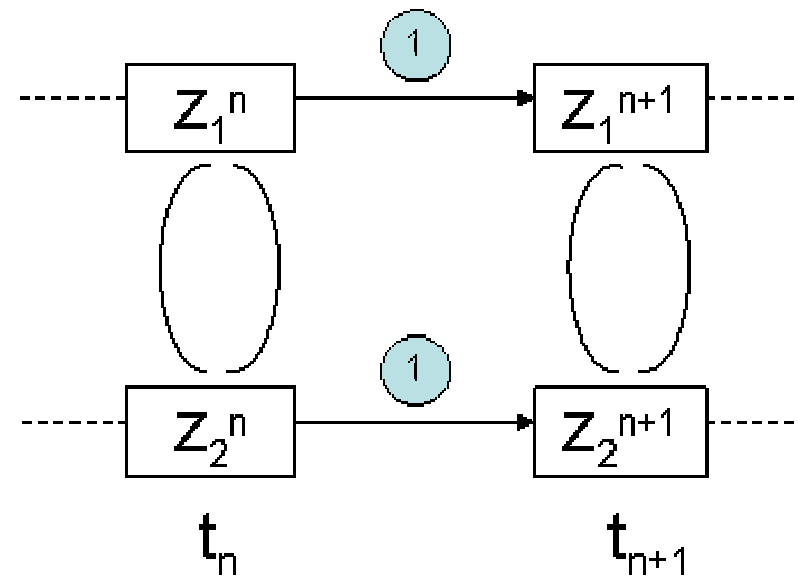
SYNCHRONIZATION PROCESS

- Stability and Data Exchange must be ensured
- Continuity (Energy) must be ensured

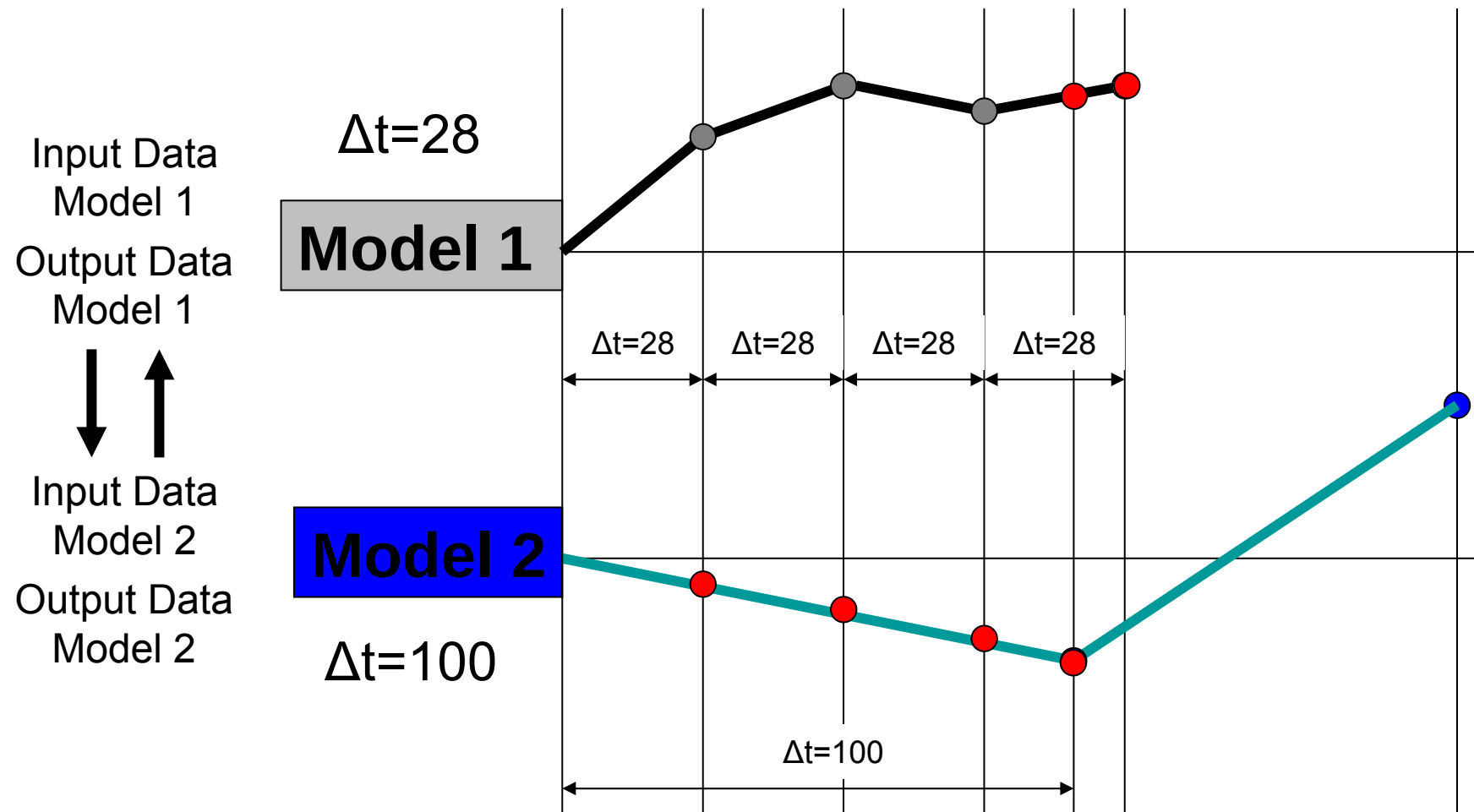
Explicit Coupling



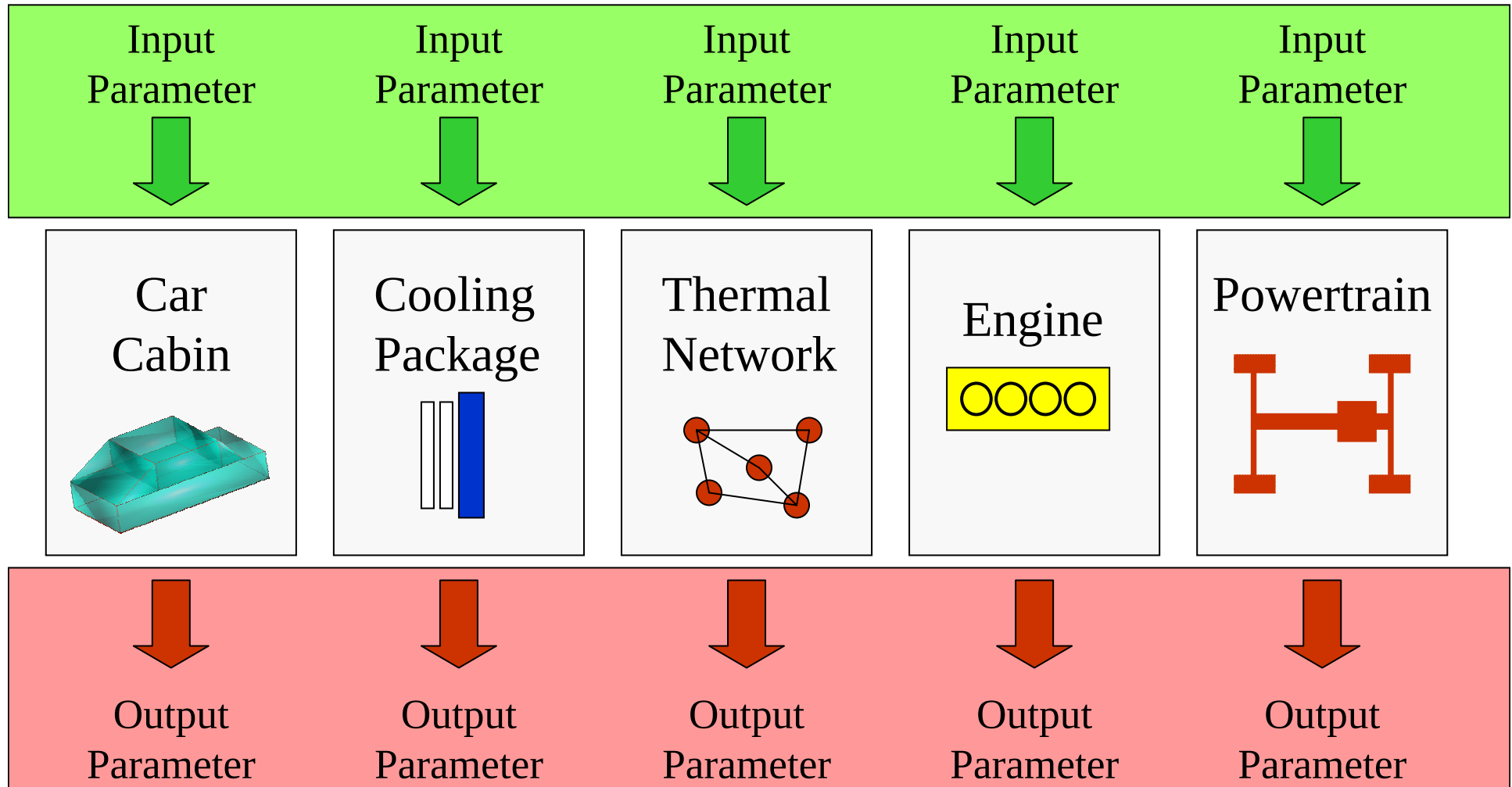
Implicit Coupling



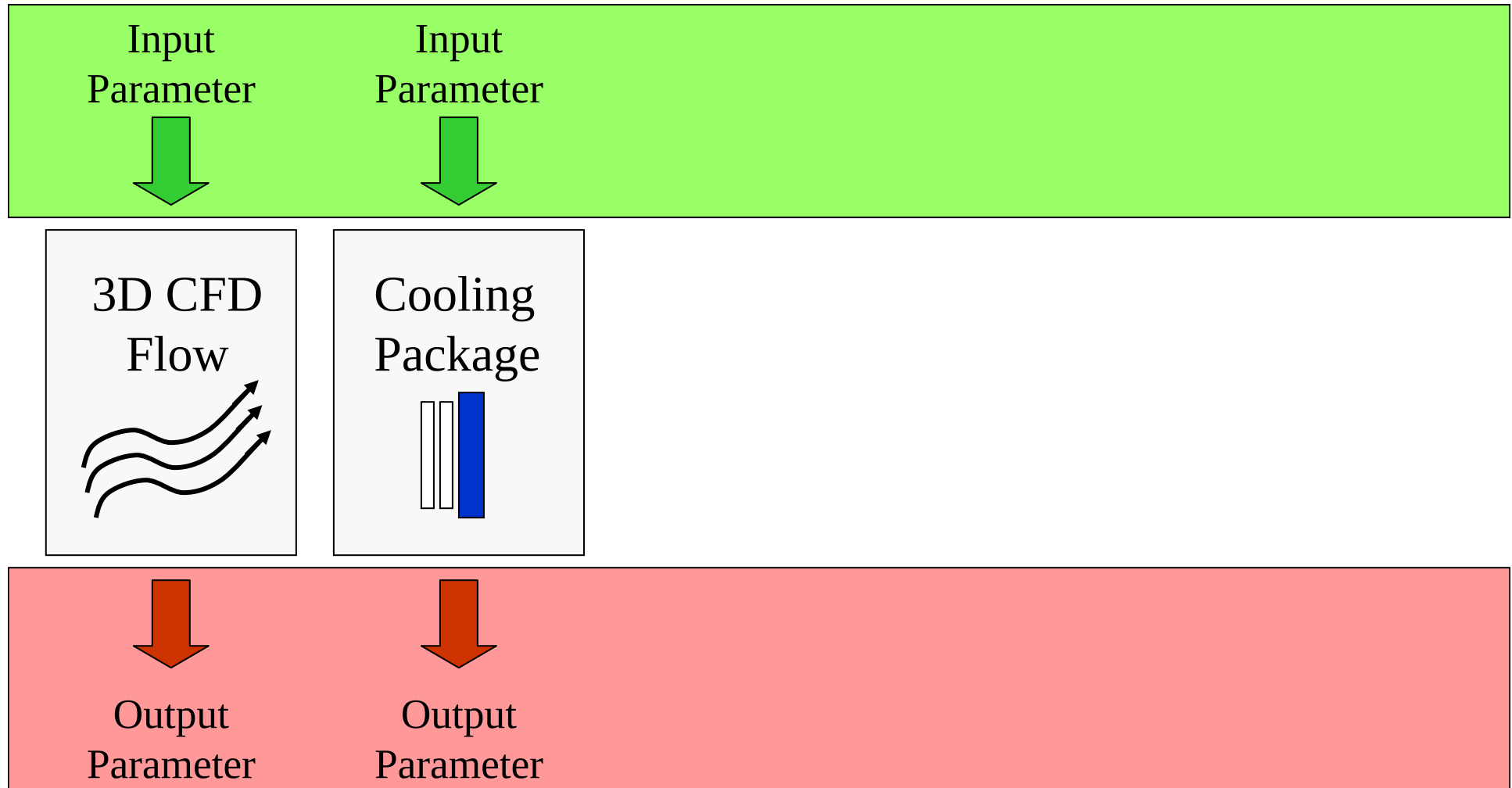
SYNCHRONIZATION PROCESS



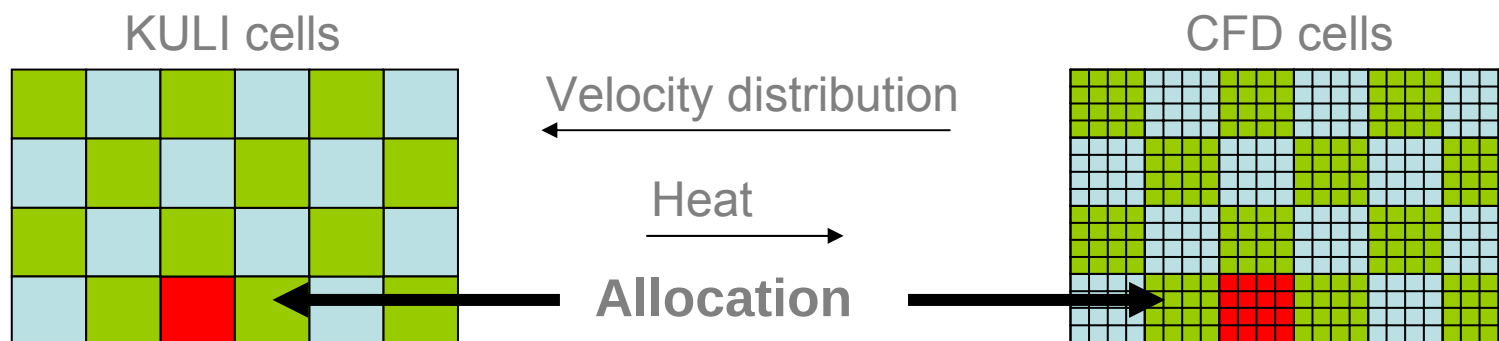
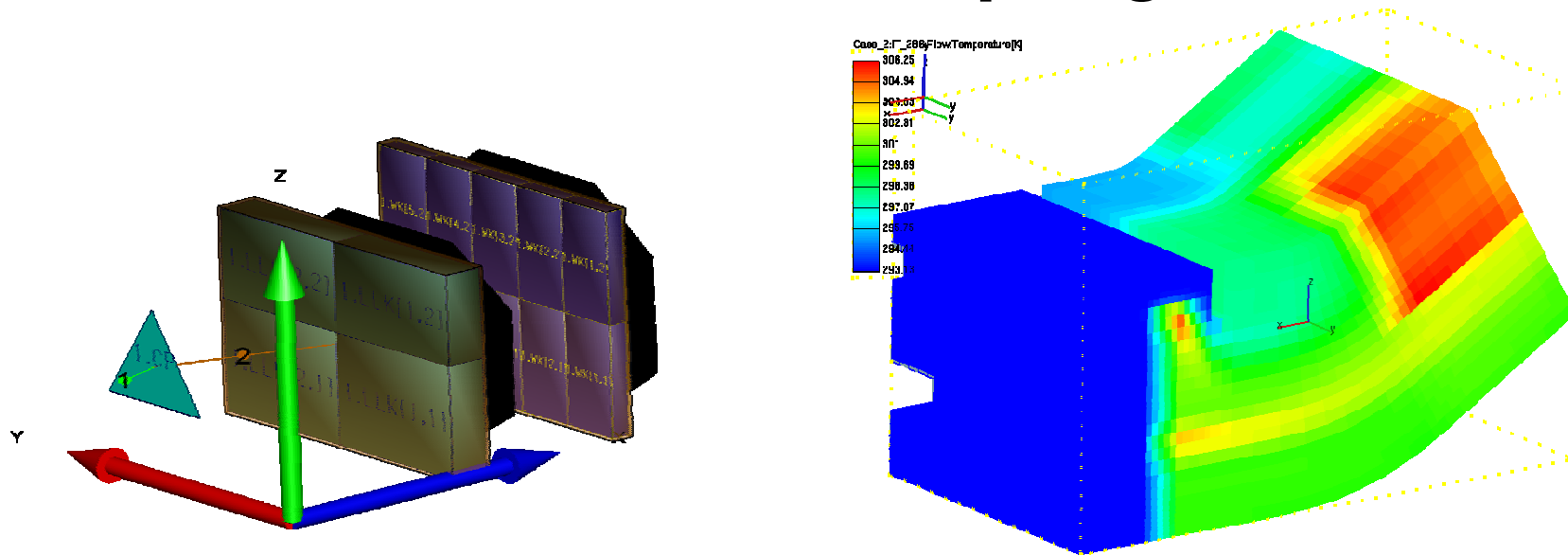
COUPLING



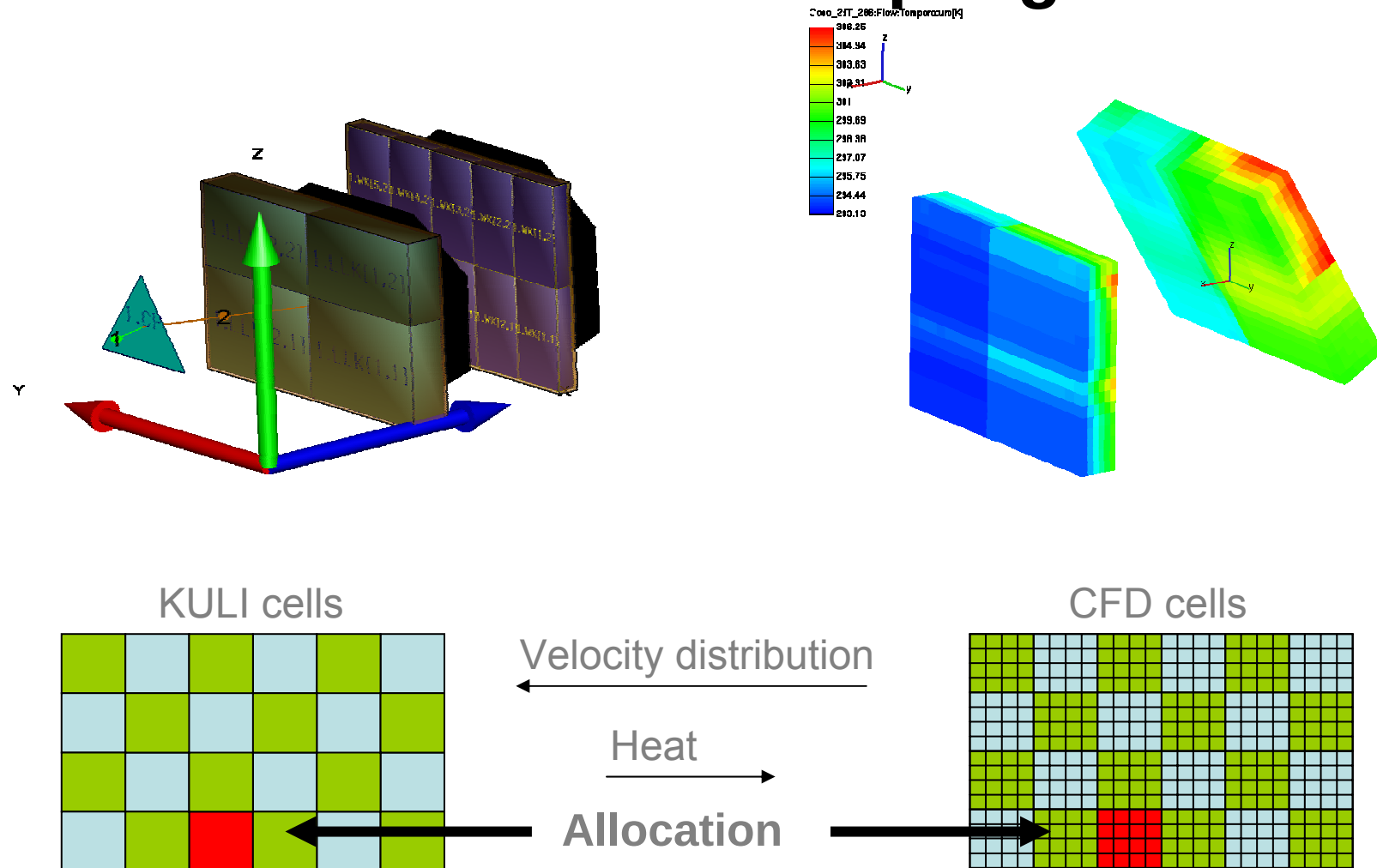
MODULARITY – 1D 3D Coupling



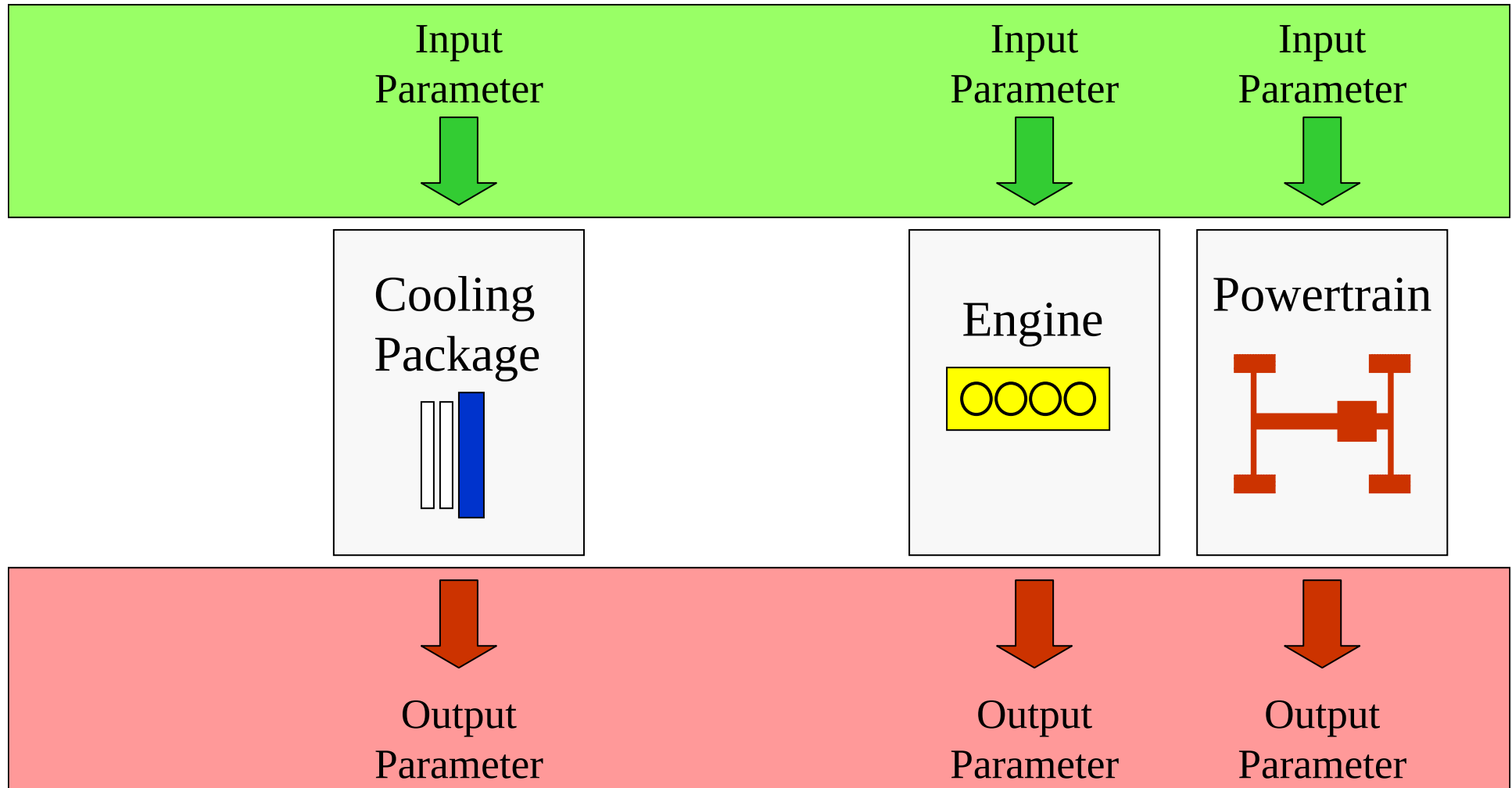
MODULARITY – 1D 3D Coupling



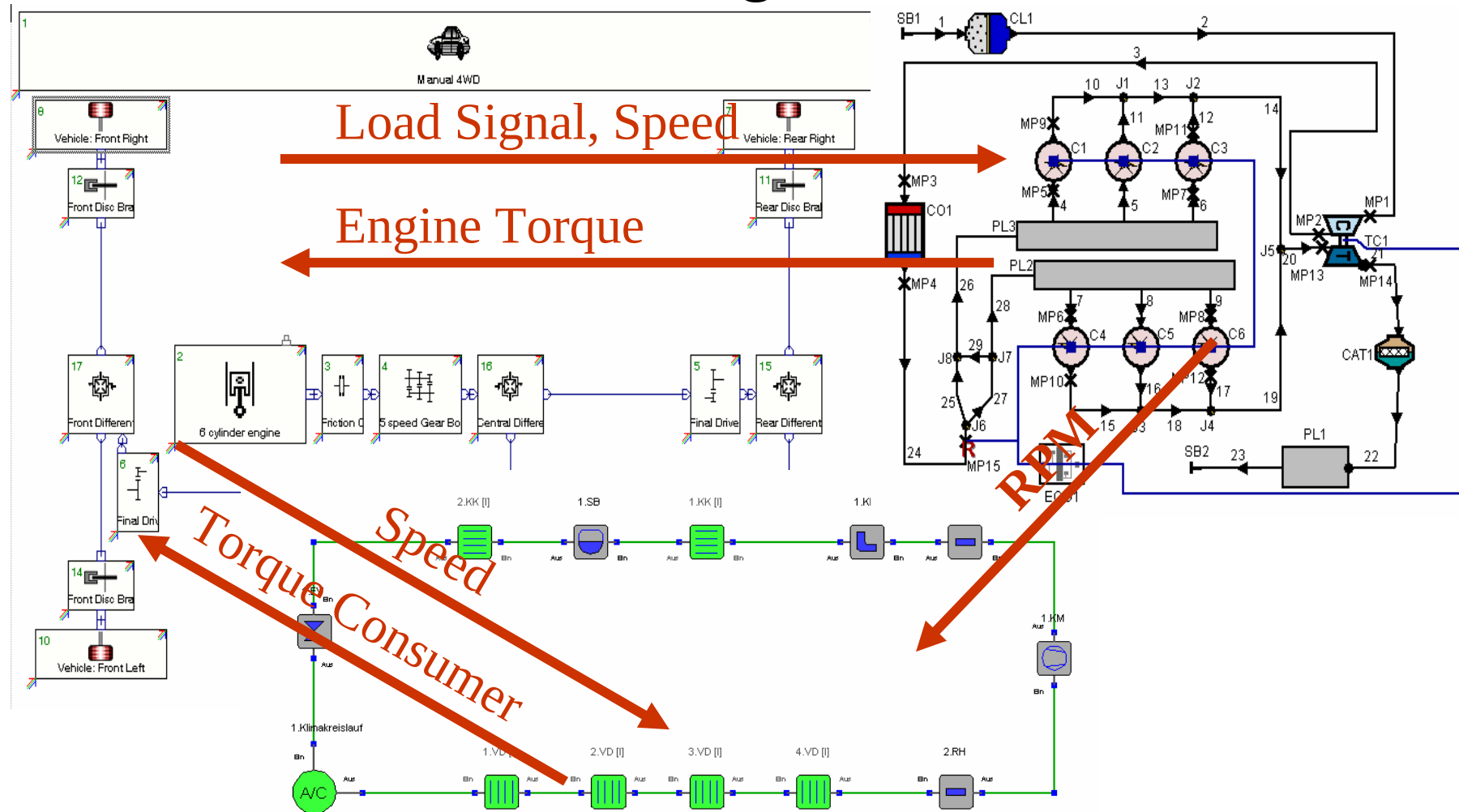
MODULARITY – 1D 3D Coupling



MODULARITY – Driving Simulation

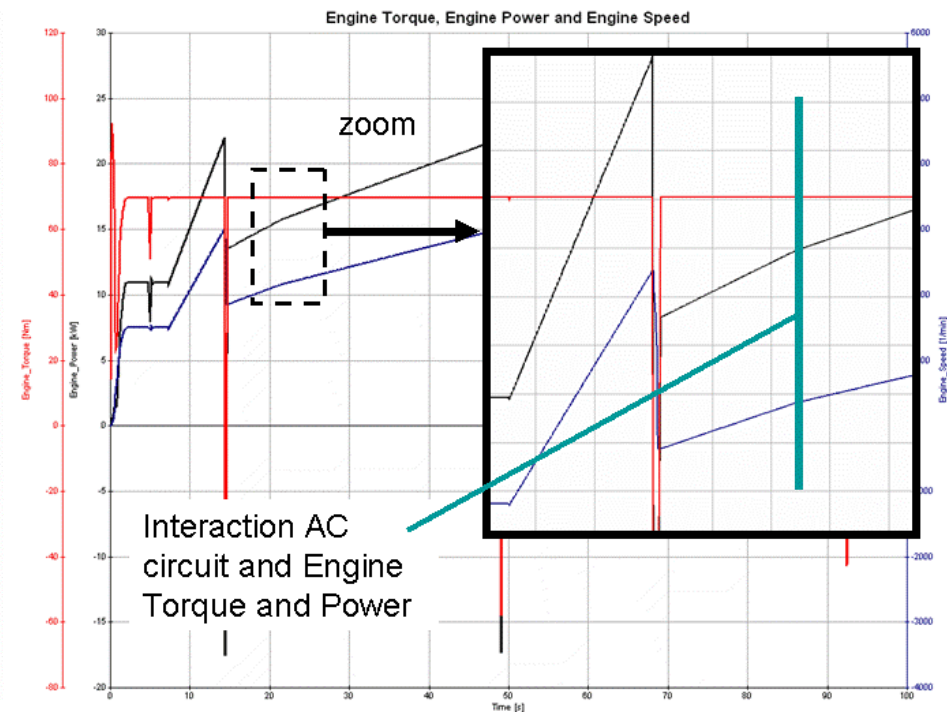
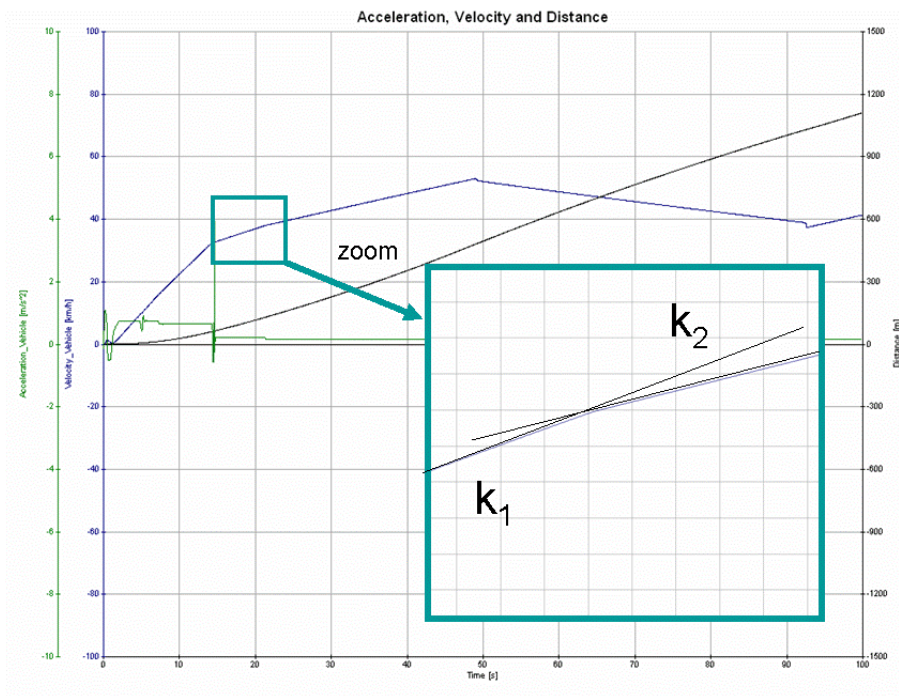


MODULARITY – Driving Simulation

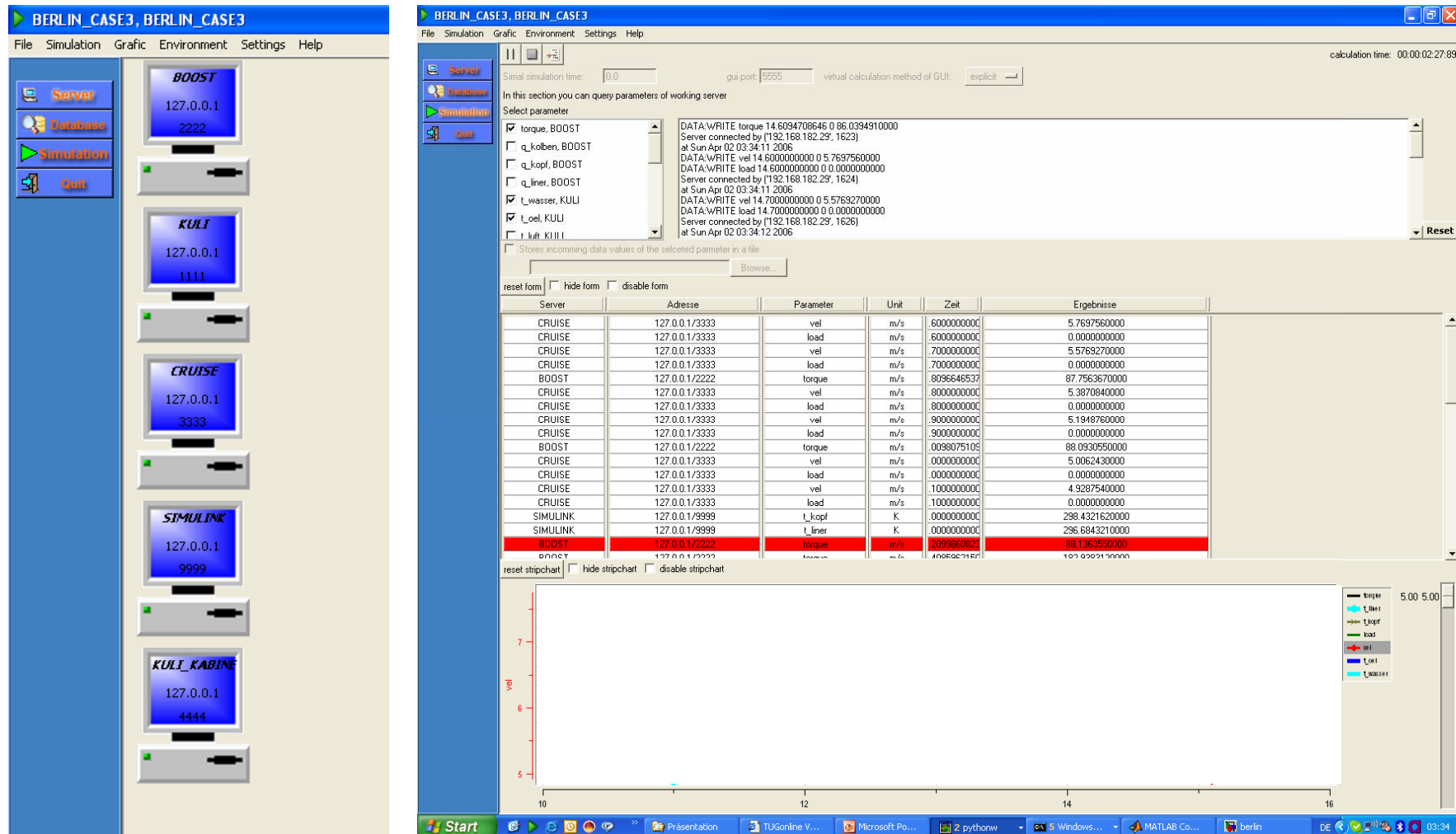


MODULARITY – Driving Simulation

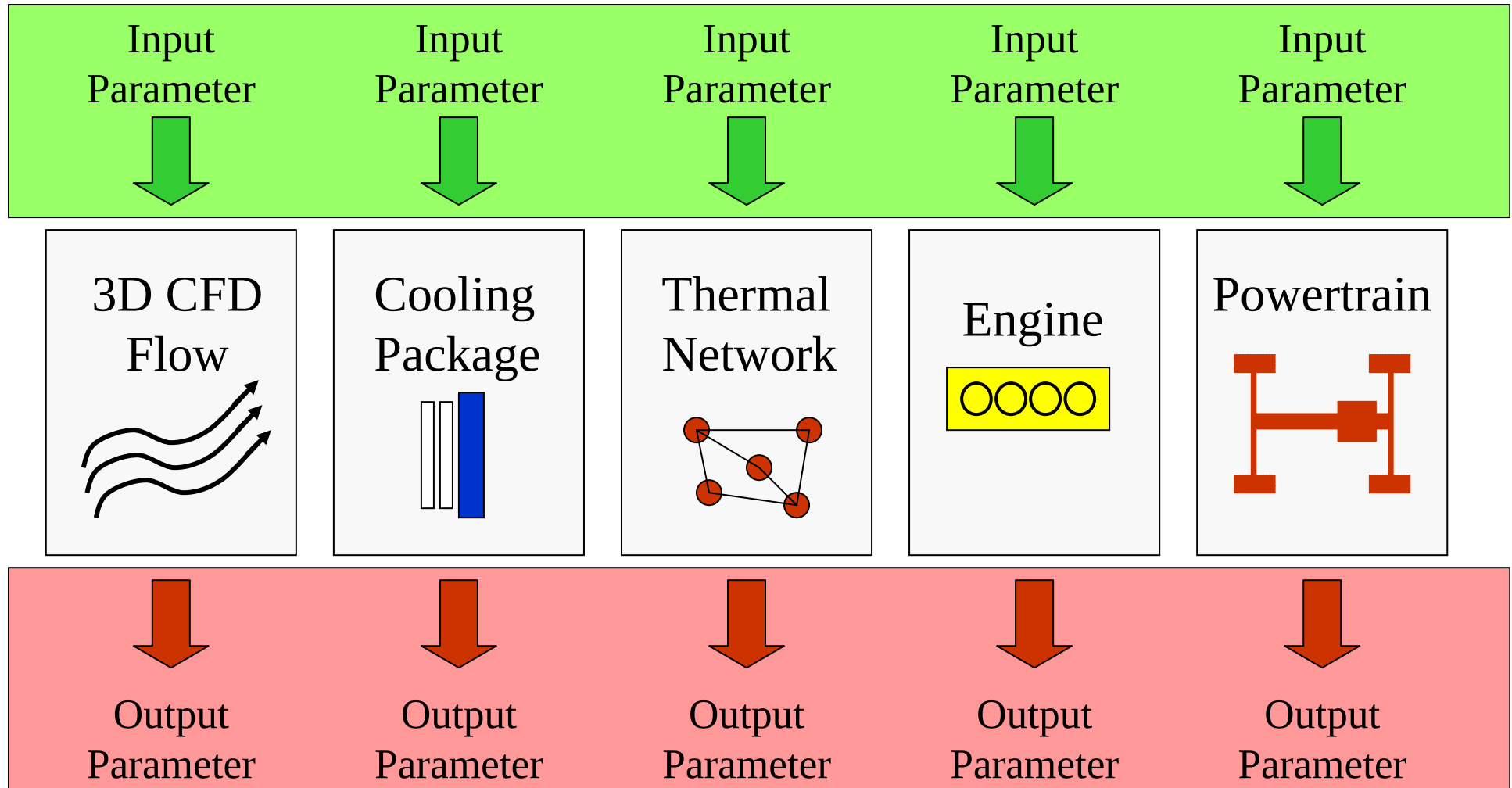
- Global transient Simulation
- Interaction between different subsystem



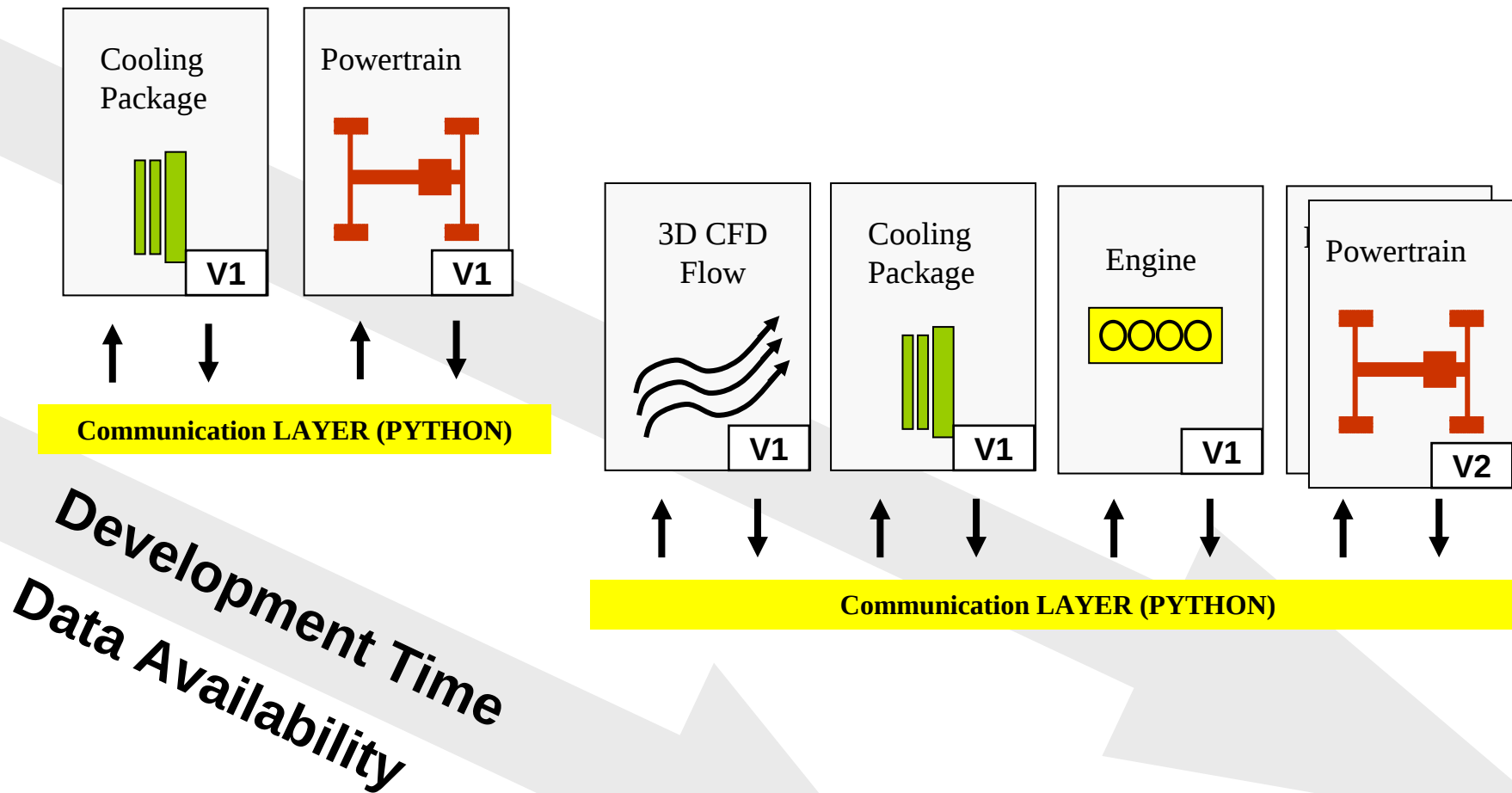
EXAMPLE – DRIVING SIMULATION



SUMMARY



SUMMARY

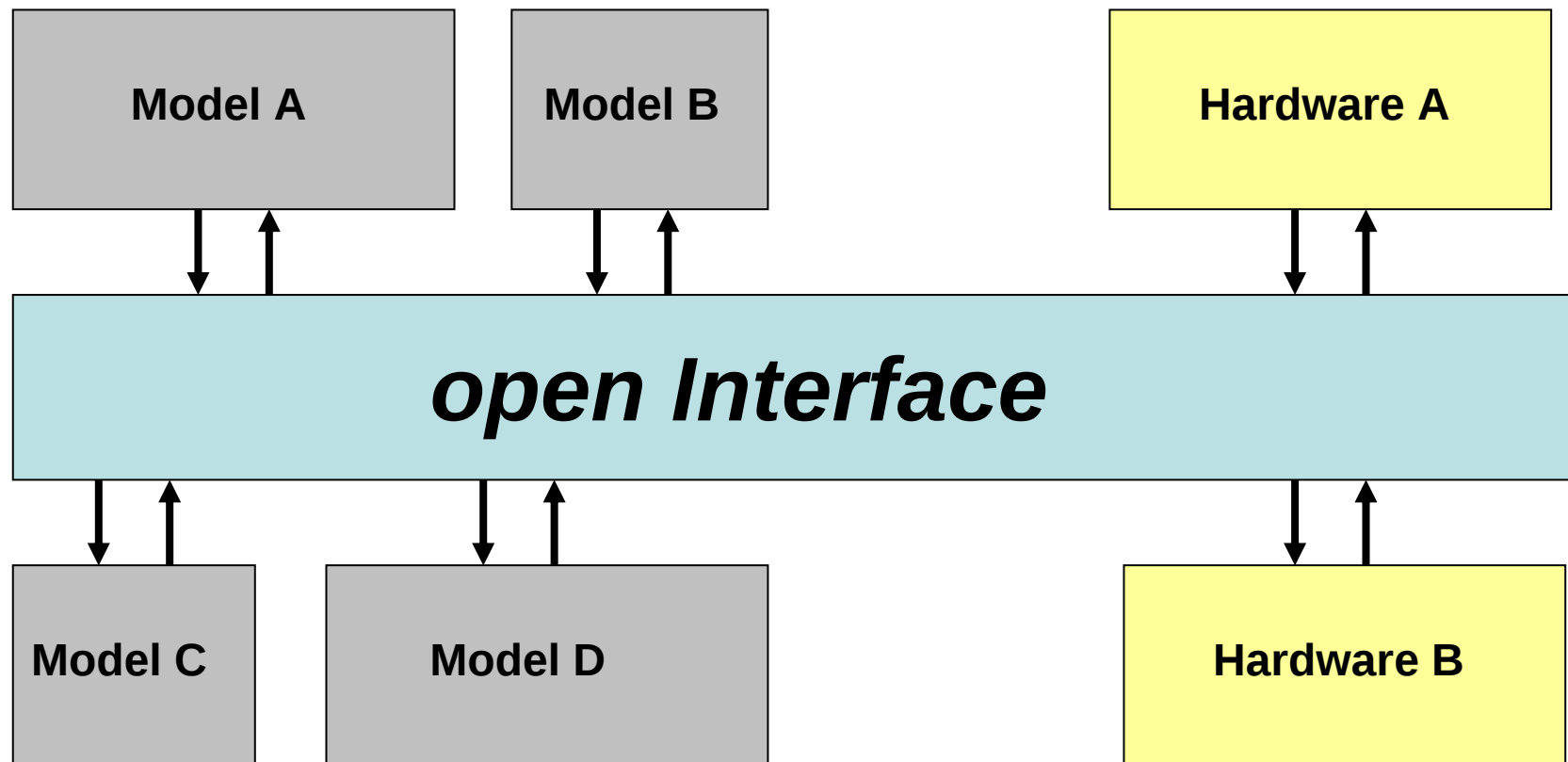


CONCLUSION

What we received ...

- Independent Coupling Approach
- Modular and Flexible Structure
- Independent from Simulation Models and Simulation Programs
- Approach for the Simulation of Comprehensive Models – Entire Vehicle

OUTLOOK - VISION



ACKNOWLEDGEMENTS



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