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Science & Innovation



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The TWT Co-Simulation framework in all-electric aircraft applications

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Confidential

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Bildquellen: TWT GmbH, iSSE project



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TWT.Inside **Management Summary**

„Technisch-Wissenschaftlicher Transfer“

Since 28 years Innovation Partner
of the Hightech-Industry

250 employees

14 running research projects

Executives:

Dr. Dimitris Vartziotis

Joachim Laicher

Frank Beutenmüller

Dr. Victor Fäßler



DAIMLER



PORSCHE



Audi



BOSCH

AIRBUS
GROUP



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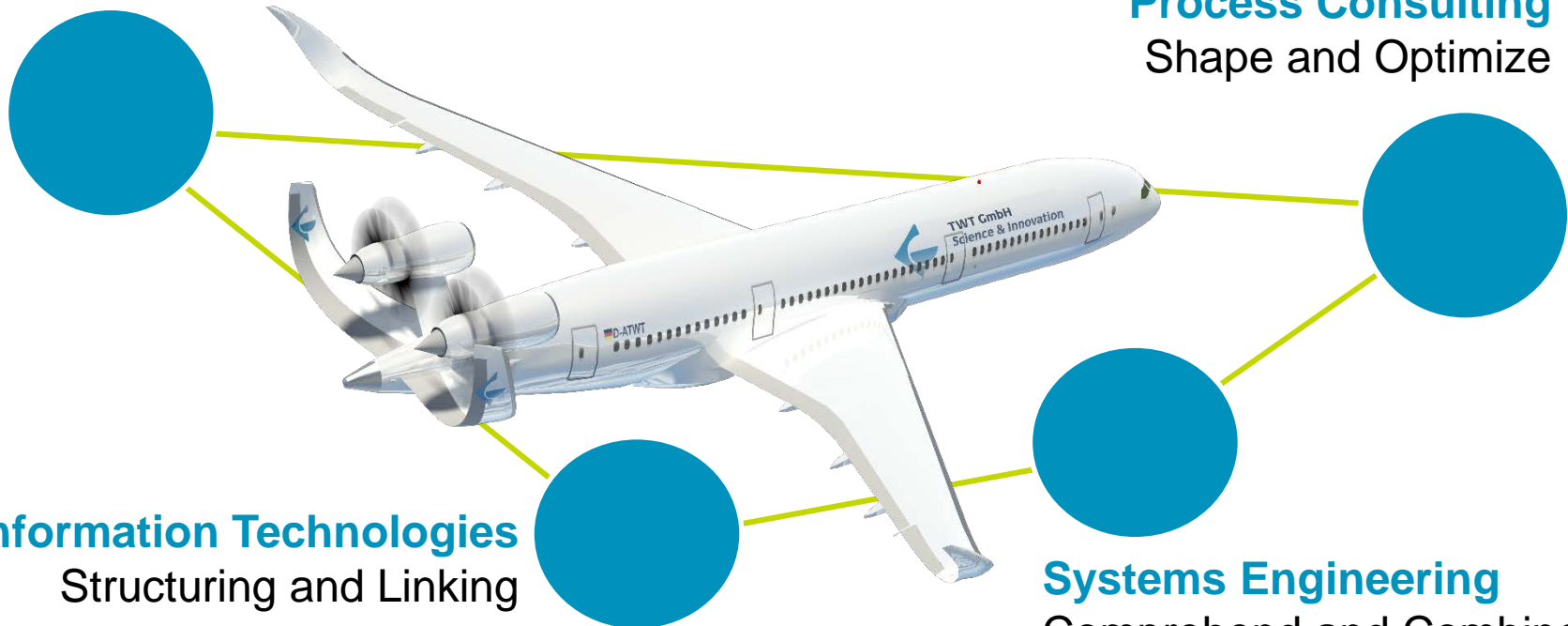
TWT.Insight **Business Activities**

Digital Development
Design and Validation

Process Consulting
Shape and Optimize

Information Technologies
Structuring and Linking

Systems Engineering
Comprehend and Combine





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Challenge: all-electric aircraft simulation

The next generation of all-electric aircraft demands intelligent power-management

Variable power distribution is safety critical and needs careful testing

Testing in the early design phase is ideally done by simulation

Full system simulation is computationally very demanding

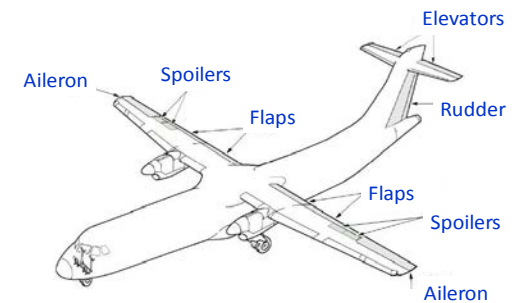




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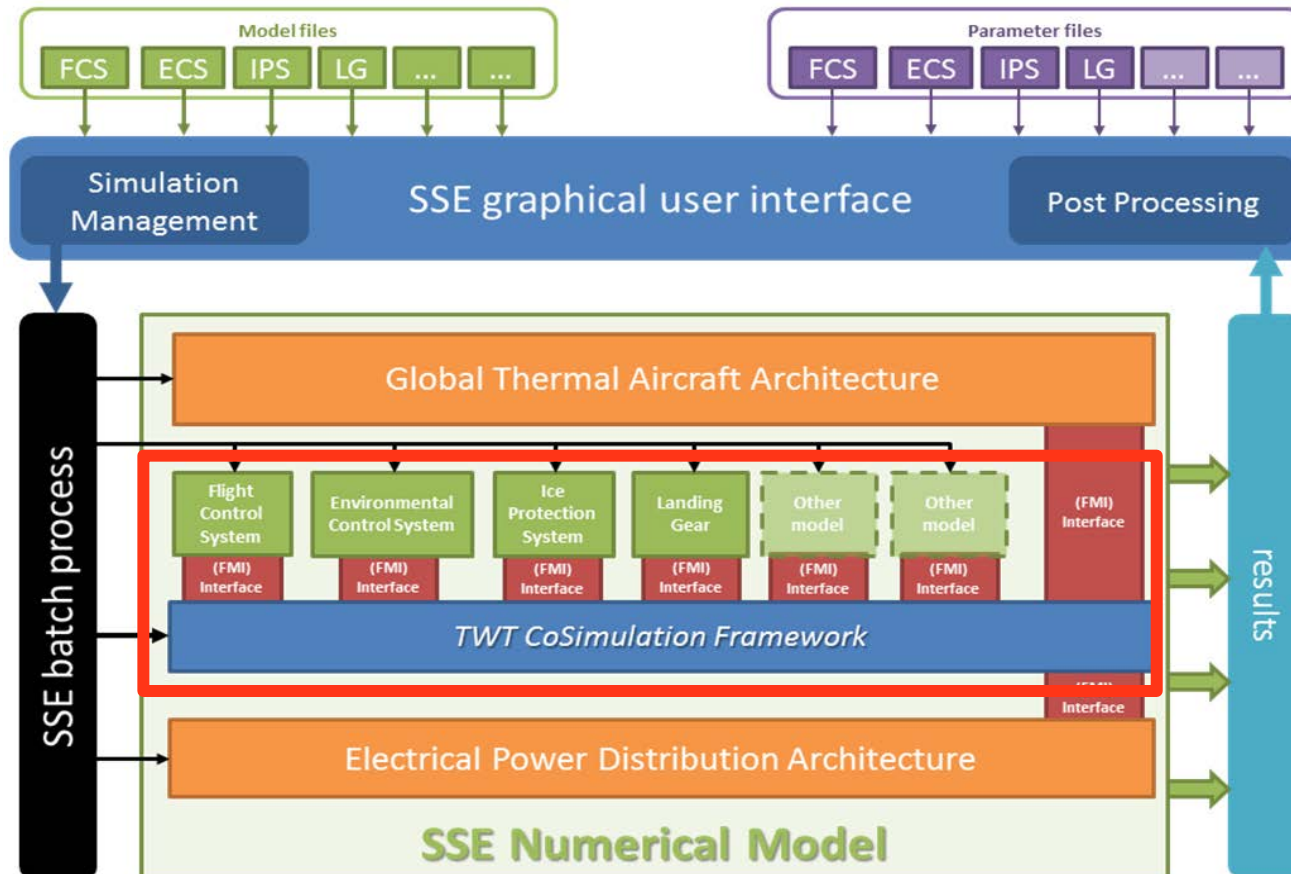
What sort of Models?

Energy Management System (EMS), & Electrical Power Distribution System (EPDS) **Dymola/Modelica**
Cabin Thermal model (CT) **AMESim**
Fuel System (FS) **Flowmaster**
Ice Protection System (IPS) **Dymola/Modelica**
Environment Control Sys. (ECS) **Matlab/Simulink**
Electrical Power Gen. Sys. (EPGS) **Synopsis Sabre**
Flight Control System (FCS) **Dymola/Modelica**
Landing Gear System (LGS) **Dymola/Modelica**





Shared Simulation (iSSE project)





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Feature summary

The *TWT Co-simulation framework* manages signal exchange between

- *multiple simulations*, running in
- *different tools*, possibly located on
- *multiple hosts*

Written in *Java* using modern, efficient libraries

Provides a control and monitoring GUI

Provides Connectors for several common simulation tools



Based on Modelisar FMI

FMI model description standards are used to describe

- simulations
- their signals

Generation of FMI model descriptions for several tools

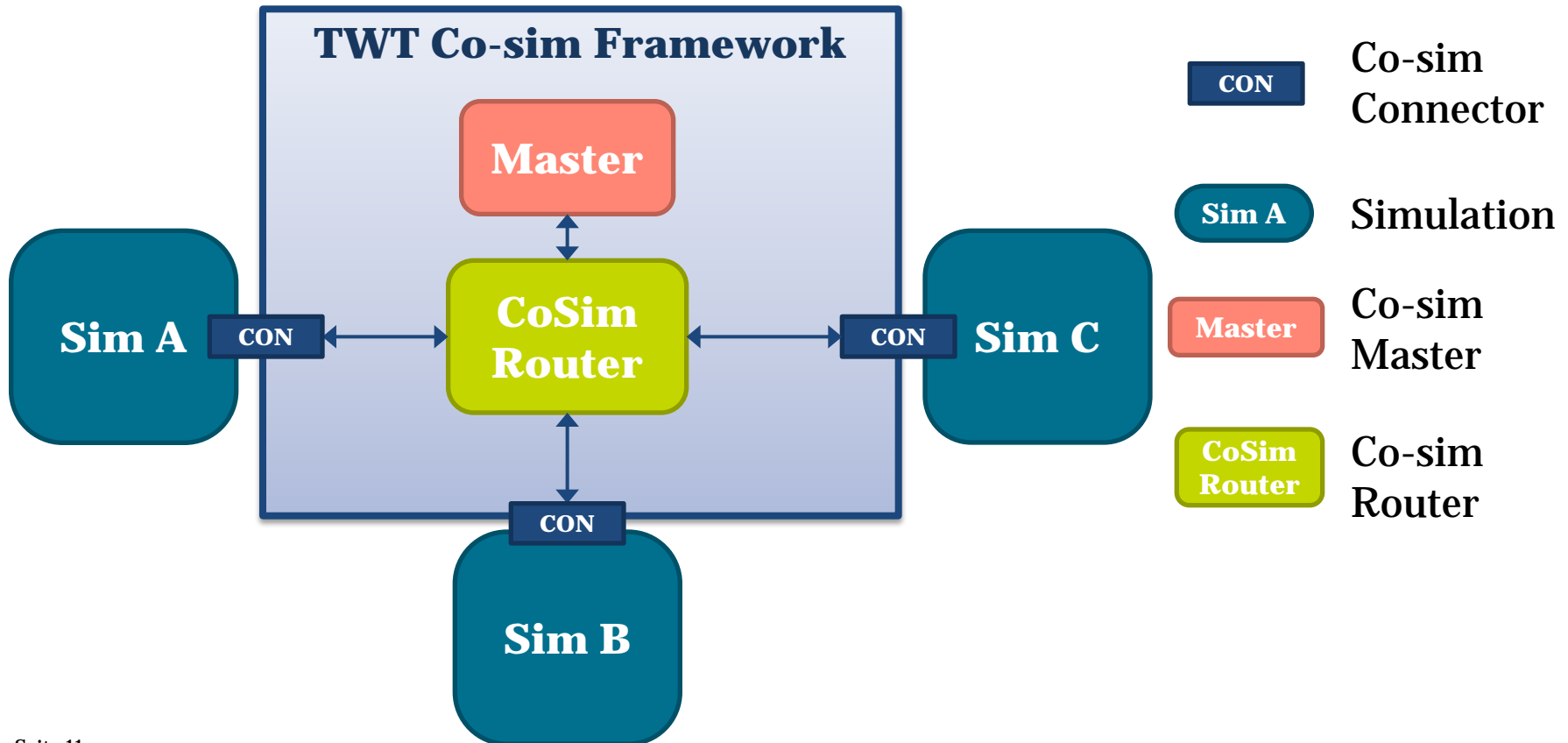
FMUs can be included

- directly via the framework FMU connector
- via the TWT Matlab/Simulink FMU Interface
- via the *Functional MockUp Trust Centre (FMTC)*



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Framework structure





Framework components

CON

Co-sim Connectors:

- Connect a simulation to the framework
- Multiple available methods to integrate with simulations

CON

Co-sim
Connector

Sim A

Simulation

CoSim
Router

Co-sim Router:

- Communicates with all simulations via their connectors
- Forwards sent messages to specified recipients

Master

Co-sim
Master

CoSim
Router

Co-sim
Router

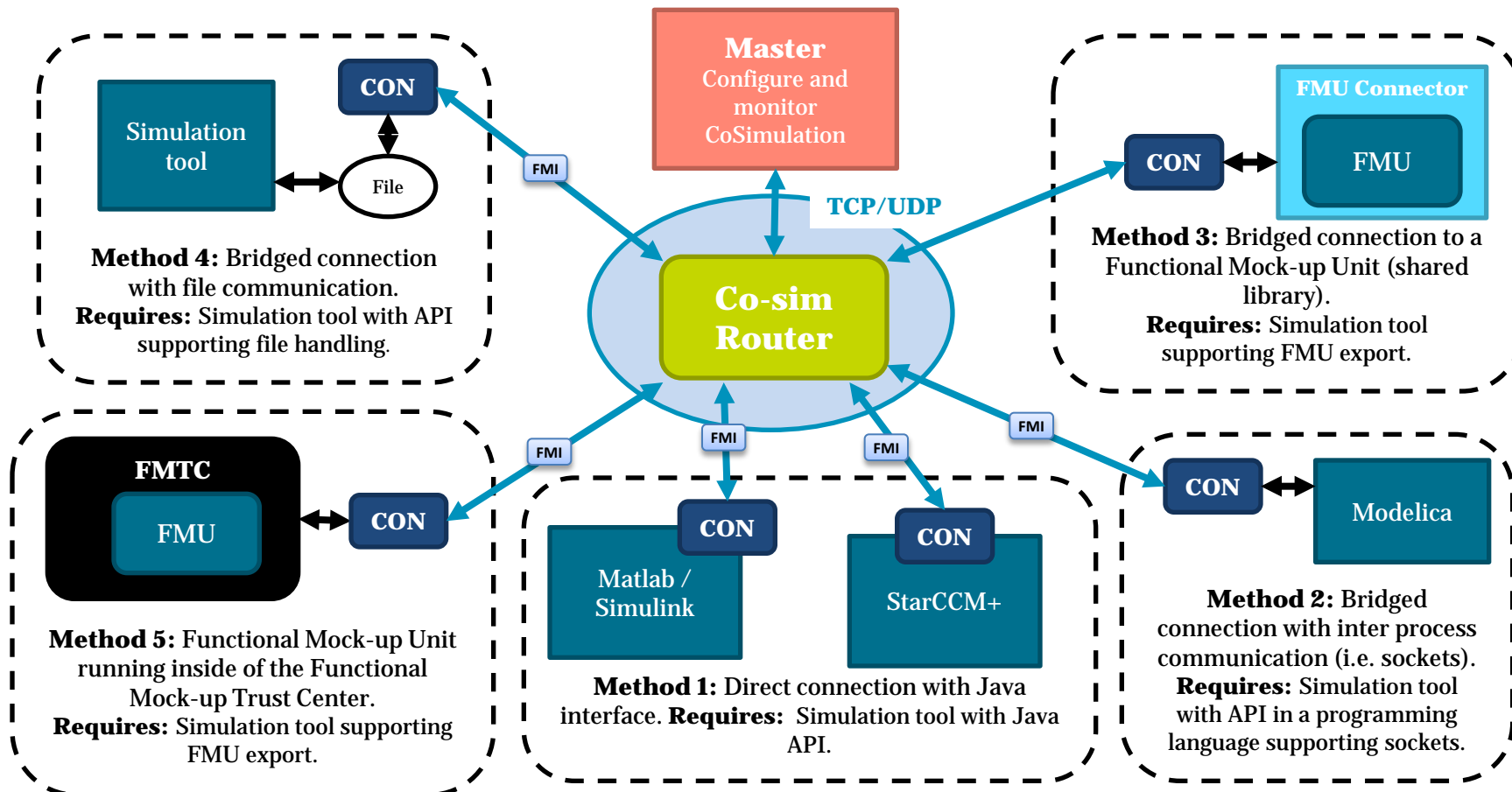
Master

Co-sim Master:

- Allows controlling and monitoring the co-simulation
- Provides a GUI

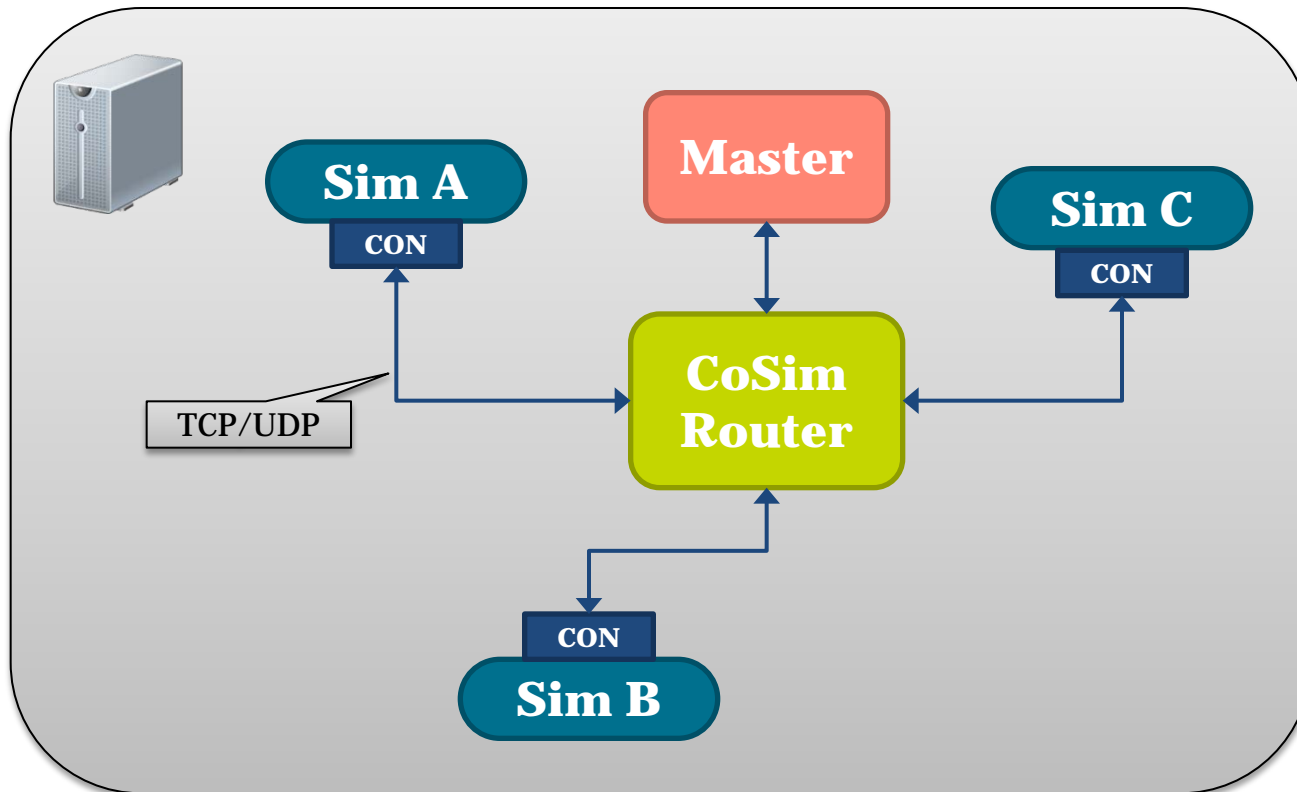






Existing simulation integration methods





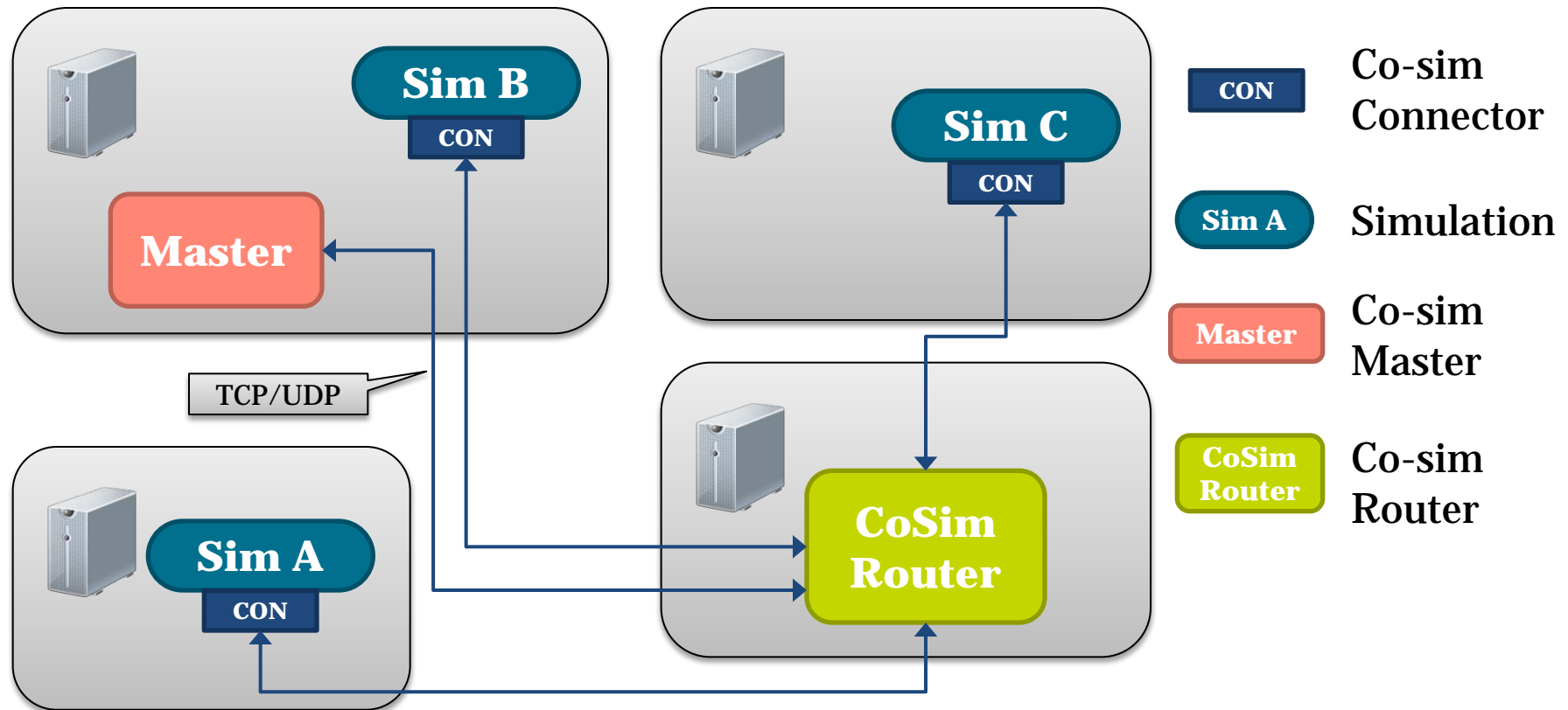
Network topologies – single host



-  Co-sim Connector
-  Simulation
-  Co-sim Master
-  Co-sim Router

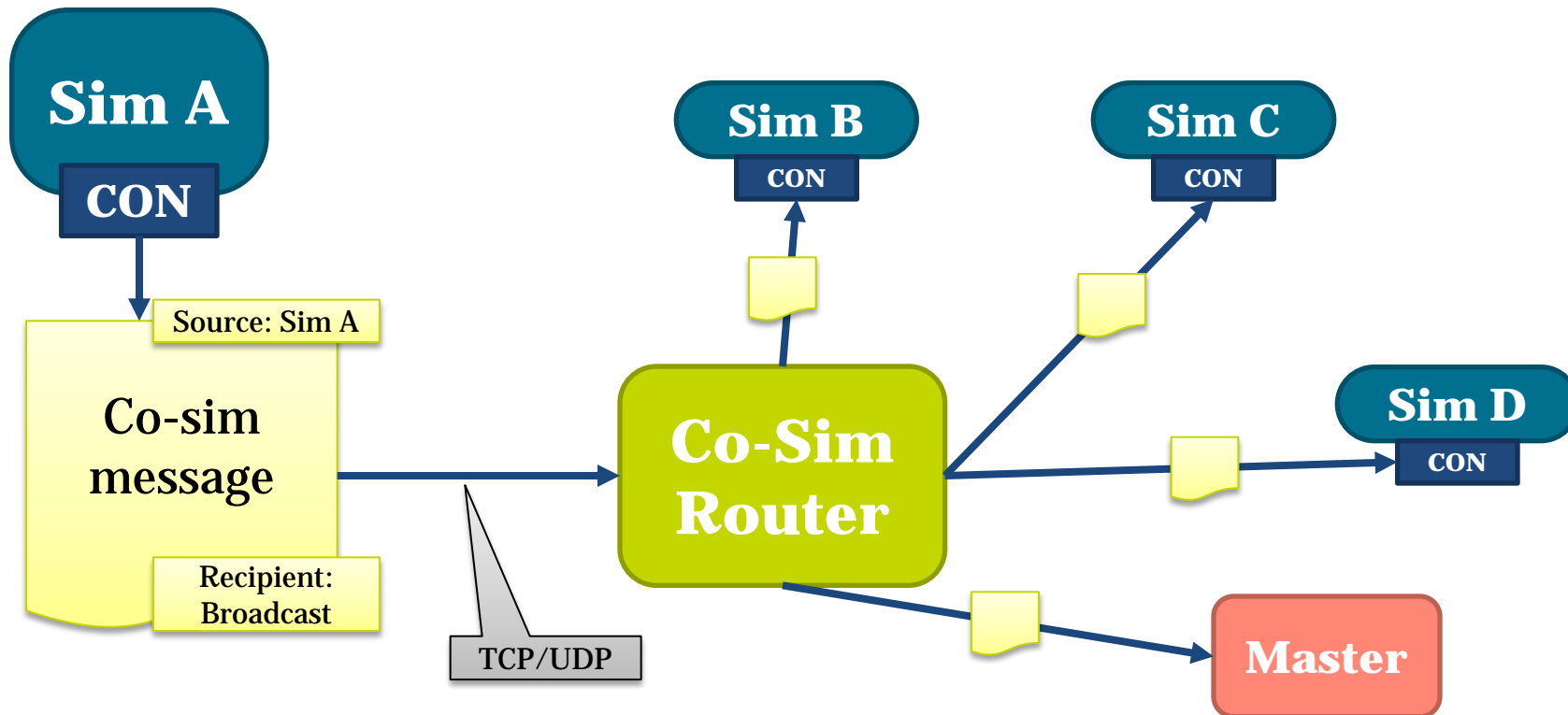


Network topologies – multiple hosts (LAN)



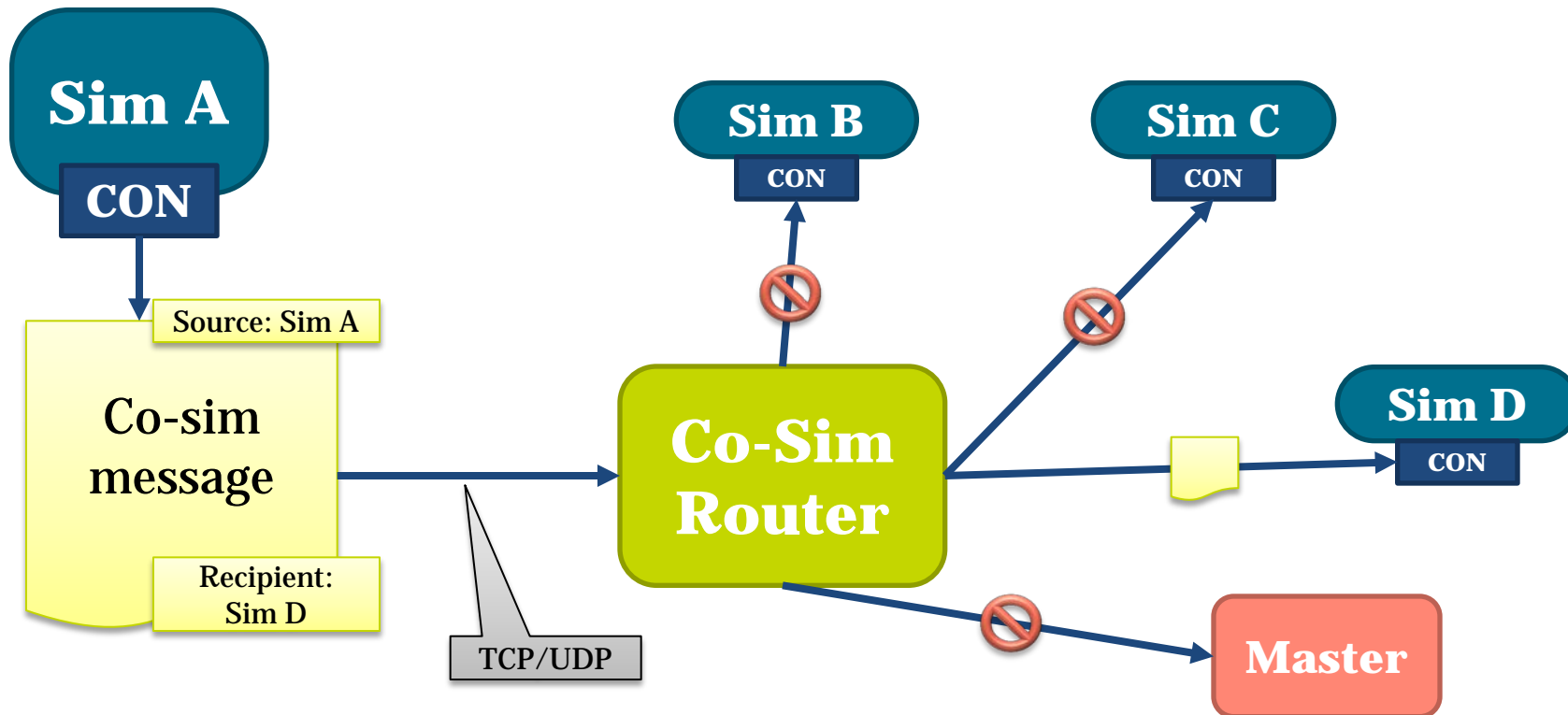


Co-Sim Router: Message flow (broadcast)





Co-Sim Router: Message flow (single recipient)





Message types

State messages: a simulation communicates its current state

Command messages: the master sends a command to one or multiple simulations

Information requests: (new) simulations request information about the other co-simulation members

Information messages: a co-simulation member sends various information *including its FMI model description*

Signal messages: simulations send the current values of their output signals



Constraints on communication step size

The chosen communication step size is

- fixed
- the same for all simulations
- computed as the least number which is
 - a multiple of at least two step sizes and
 - a divisor (or multiple) of all other step sizes

→ if all step sizes are identical, that step size is chosen



Setup routine

1. Router process starts
2. Master process (GUI) starts, registers with Router
3. Simulators initialize, register with Router
4. Simulators synchronize (signal mapping, stepsize)
5. Co-Simulation starts, repeated exchange of signals
6. Simulators can be paused and resumed



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Co-Simulation live





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The TWT Co-Simulation framework ...

... is able to integrate various data formats

... is able to integrate tools via FMTCs to protect intellectual property

... is appropriate for various applications, such as all electric aircraft, automotive energy management etc.