MÄLARDALENS HÖGSKOLA
ESKILSTUNA VÄSTERÅS

MRTC
MÄLARDALEN REAL-TIME RESEARCH CENTRE

Execution modeling

The missing leg in model-based development of performance-oriented embedded systems

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Arcticus Systems

Affiliations

- Mälardalen Real-time reserach Centre
  - Research centre at Mälardalen University
  - Internationally competitive research in component- based software engineering and real-time
  - 13 Professors, 20 Senior Researchers, 45 PhD students
- Arcticus Systems AB
  - State of the art development tools for dependable real-time system
    - Developed in close cooperation with MRTC for over 15 years
  - Rubus Intgrated Component development Environment
    - Design, Analysis and Synthesis tools and OS

Model based development (MBD)

- Emerging approach for embedded real-time systems
  - Handling increased complexity of products
  - Shortening development cycles
  - Addresses quality concerns
- This is, we believe, a healthy trend
  - Reason about a system
    - On various levels of abstraction
    - Early in the development process
  - Generating code directly from models

Traditonal MBD

- Structural modeling
  - UML – class diagram, sequence diagram, use cases
- Functional modeling
  - Statemate
  - Matlab/simulink
  - UML statemachines
- Push the button => Runnable system

HOWEVER!

No Idea of run-time properties!

Detrimental for performance critical systems

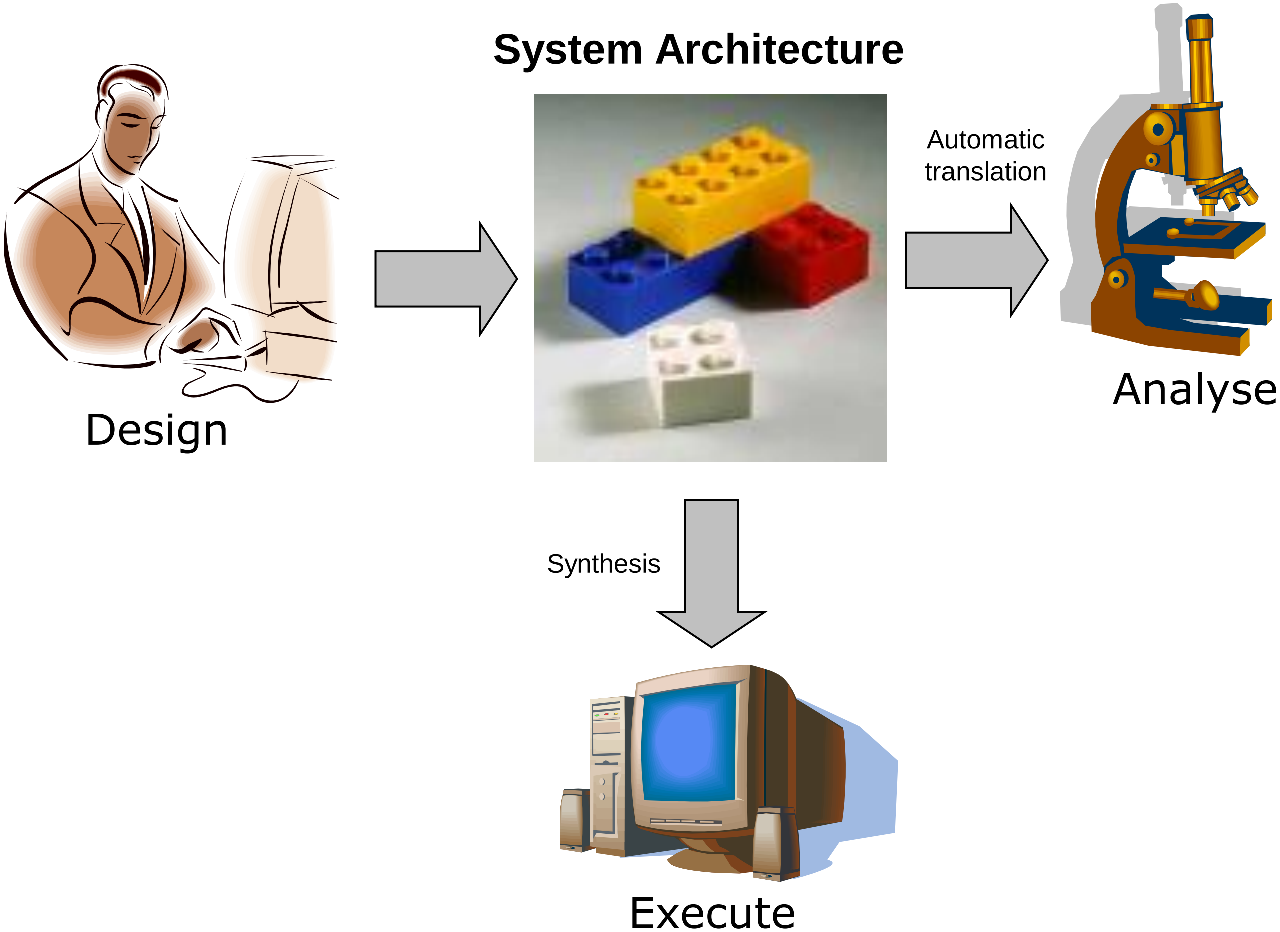
The missing leg: Execution modeling

- Solution
  - Promote execution to the modeling level
- Execution modeling
  - What executes?
  - When does it execute?
  - Who interacts with it?
  - How long does it take?
  - How much resources does it need?
- Information and control over these properties means that performance can be predicted and tuned

Aim and focus on execution modeling

- Concerned with the run-time properties and requirements of software functions
- Closes the semantic gap from functional behavior and execution behavior
- The developer have a direct control of the actual run-time behavior
- From a formal model that includes run-time properties an optimized run-time framework can be generated
- Control of execution details is necessary for real-time analysis as well as the overall system performance.

The development context



The system architecture

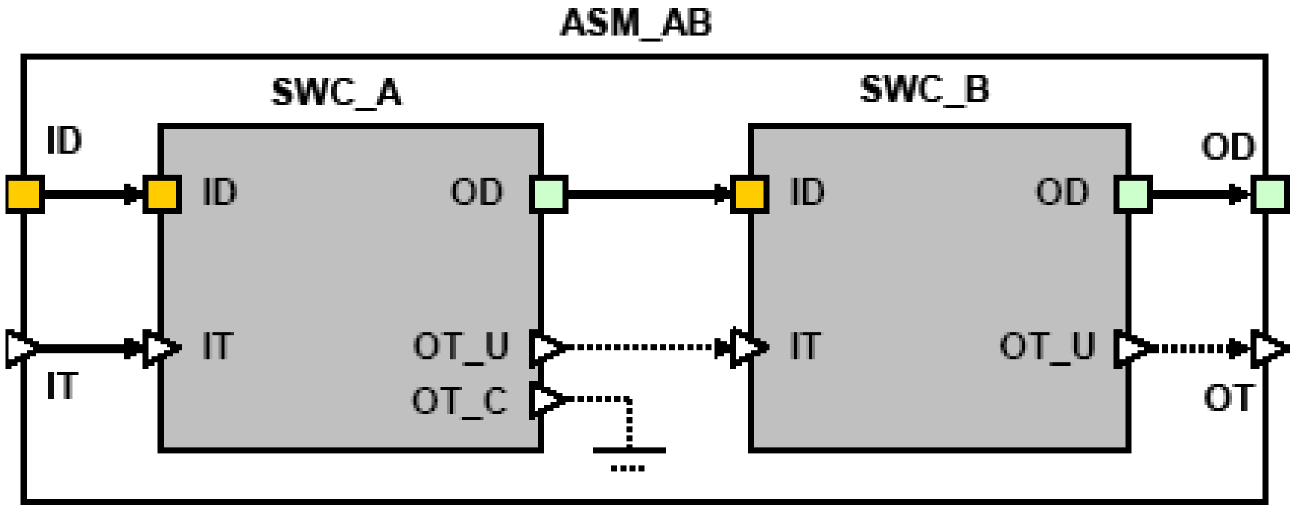
- Expresses the properties and requirements of SW Components
  - A control- and dataflow graph model of the execution environment of SWC's
    - Triggering and data dependencies
  - How SWC are triggered by clocks or events

- Real-time properties and requirements.
  - End-to-end deadlines of trigger chains
  - Precedence constraints SWCs
  - Resource usage (space and time) of each SWC

- Expressed in the Rubus Component Model (RCM)

Developers view

- Express properties and requirements for SW functions
- Control over execution infrastructure
  - Separate code and data-, control-flow
- Simple yet expressive
- Different levels of abstraction
  - SWCs, Assemblies, Composites, Modes, ...
- Different views
  - Control flow: triggering
  - Data flow
  - Real-time temporal view
    - Properties and requirements
  - Per node, system, communication


ASM_AB
SWC_A
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ID
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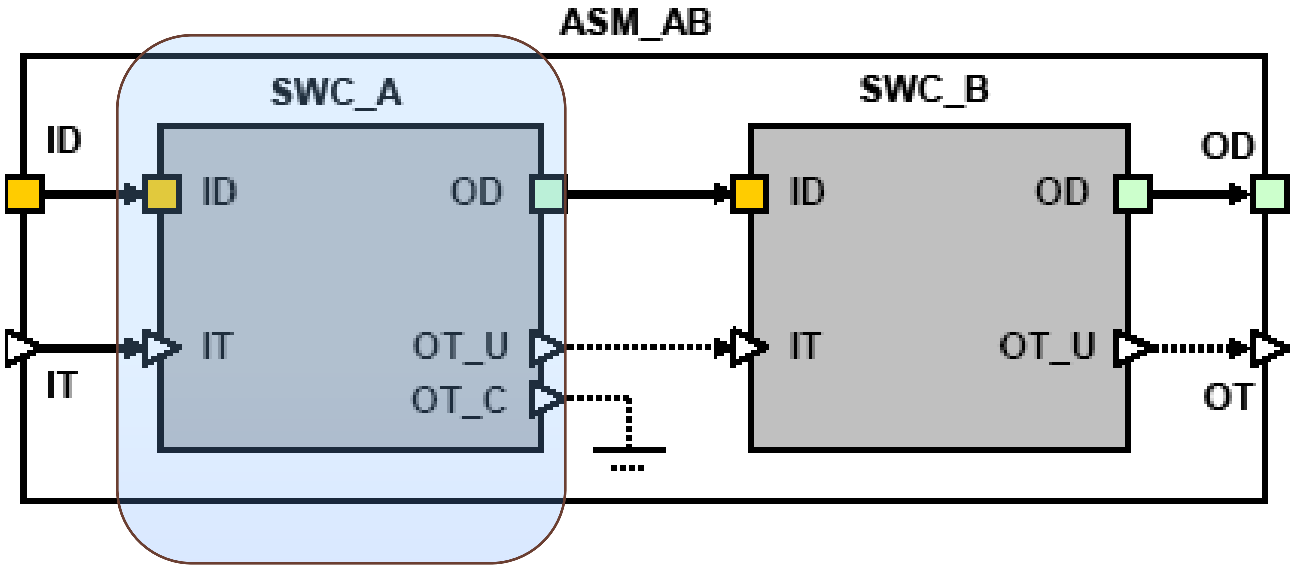
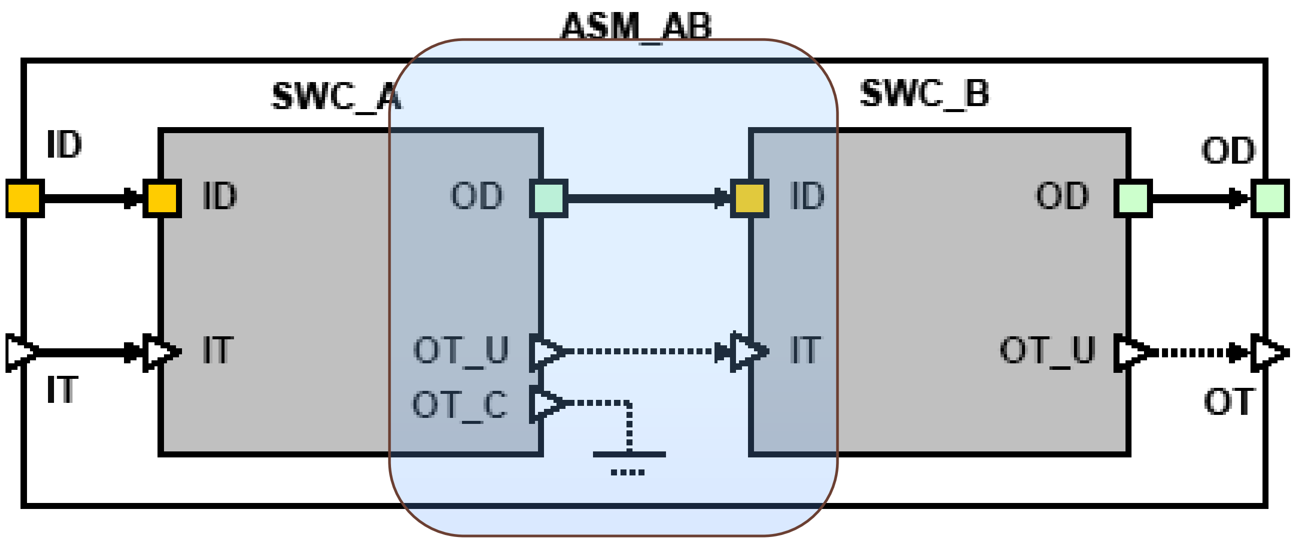
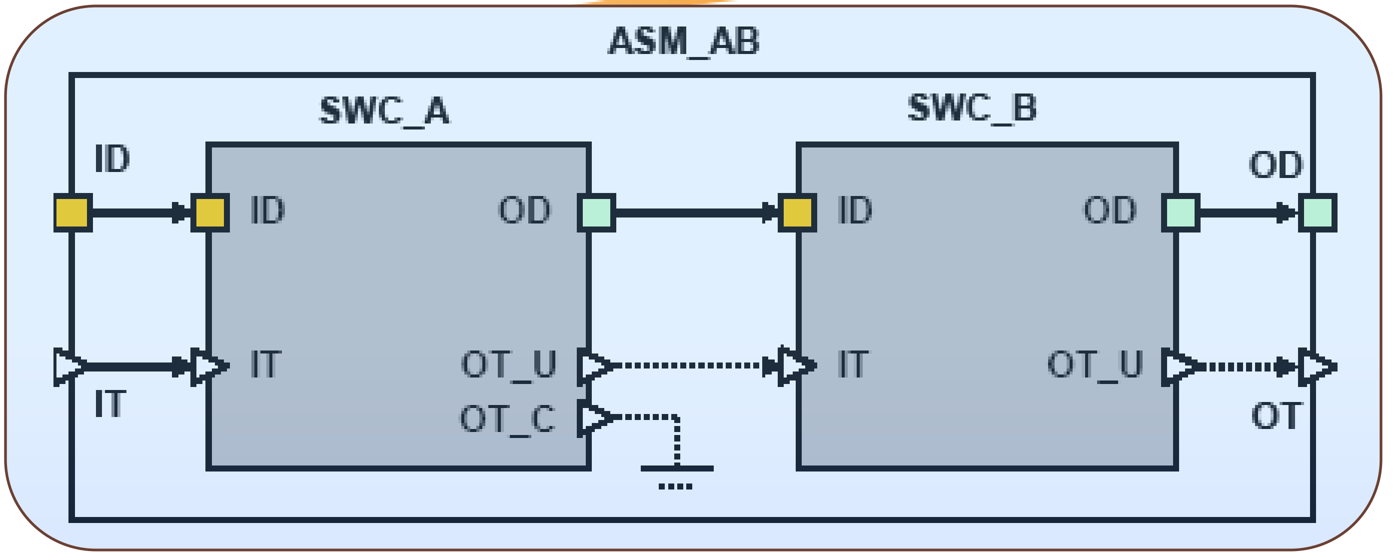


- Software Circuits
- Data ports
  - Input (n) and Output (n) ports
- Trigger ports
  - Input (1)
  - Output
    - Unconditional (1) and Conditional (n)



- Connectors
  - 1 producer – n consumers
  - Output to Input
  - Output to “sink”
  - Constant to Input



- Assemblies & Composites
- Input and output ports
  - Data (n) and trigger (n)
- Collection of
  - SWCs+ASMs
  - Their interconnections

Triggering

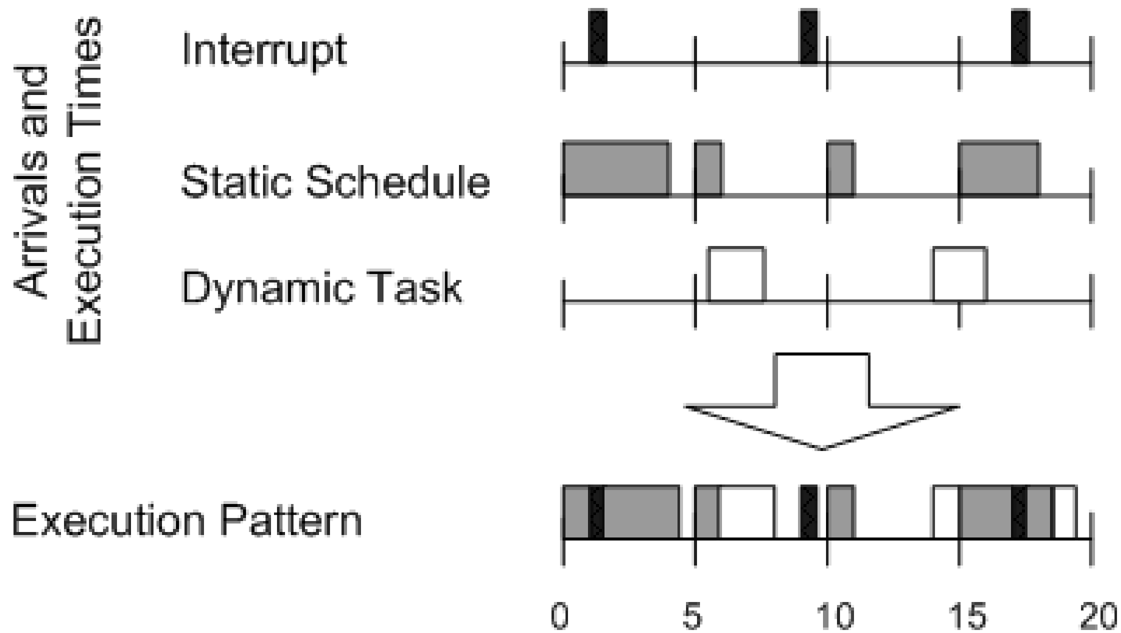
- Chains of trigger ports define precedence
- Started by
  - Clocks
  - Interrupts
  - Events (=>Unconditional Trigger Ports)
- 1-to-many
- AND to support many-to-1

View of the analysis framework

- RCM automagically tranformed to an analysable model
  - Task model with offsets
    - Temporal dependencies
    - Precedences
    - Triggering events: Period, MINT
      - Future complex triggering conditions?
    - Stack usage
- Analyse
  - Response times (TT and ET tasks)
  - Overall system stack usage required
  - Specific for Embedded control systems

View of the run-time system

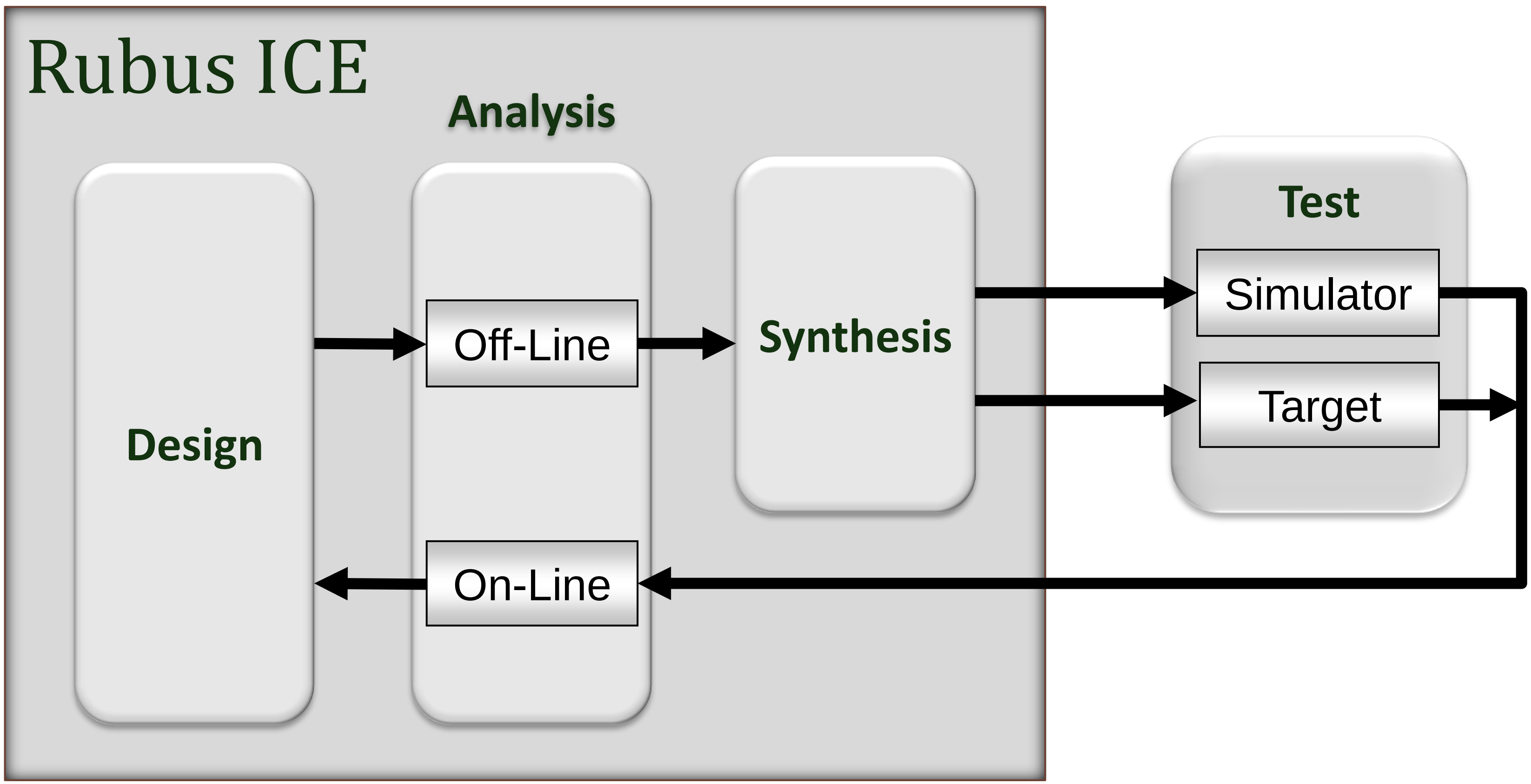
- Predictable behavior
  - Adheres to:
    - Component requirements
    - Analysis assumptions
- Low footprint



Industrially proven concept

- VCE has had 10+ years of execution modeling
  - Not a single timing fault during that time
- BAE Hägglunds
  - In the process of implementing stear-by-wire and break-by-wire
- Industrial partners over 15 years:
  - Arcticus, BAE, CC Systems, Hoerbiger, SICS, Volvo-Technology, Volvo-CE

Theory need to be encapsulated in tools



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Conclusion

- Execution modeling concerns with describing run-time properties and requirements
  - Control and understanding of the execution is in focus
- Execution modeling
  - Simplified design and verification
  - Control of execution gives predictability, reproducability and control over performnace
  - Analysis and formal guarantees
- Good experience from the vehicle domain
  - Can influence the telecom domain?
  - Might need other analysis and synthesis frameworks

Thank you!

Questions, Comments?

Execution-modeling

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