



FMI is Great - but not Magic

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FMI is great: Why we love it!

- Standardized, open, vendor-neutral API
- Convenient container for handling simulation artefacts: storing, sharing, archiving...
- Free simulation users from modeling/generation tool knowledge
- Reduce IP sharing

- A new quality of simulation is attainable now, because:
 - Producing, sharing and using simulation components is simpler than ever
 - Coupling multi-disciplinary simulations is now more efficient than ever



Before FMI



With FMI



What we want

FMI is great: But not magic!

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Before FMI



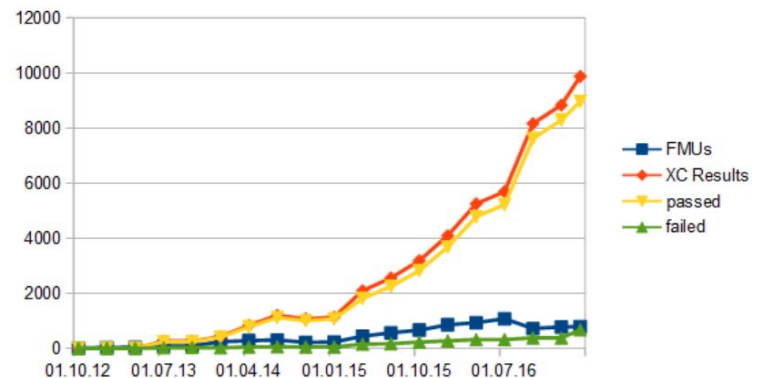
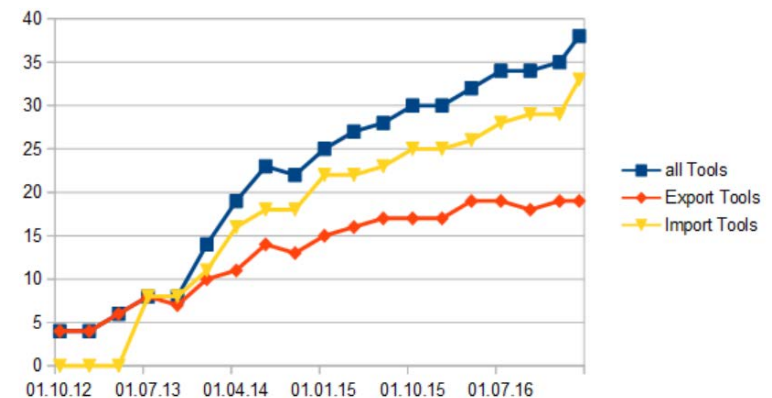
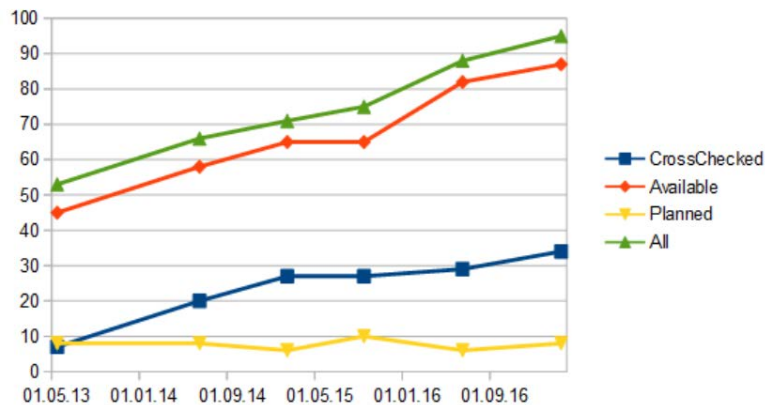
With FMI



What some of us get

FMI is great: What works

- Single FMU exchange between many, many different tools: most of the time
- FMI quality initiatives improve tool implementations:
 - FMI Cross-Check
 - FMI Compliance Checker
 - Reference FMUs
 - FMI Plug-Fest(s)




Continuous effort: Managing expectations

- Yes, FMI is great and should be part of each company's virtualization strategy
- But we need to communicate clearly:
 - What can be done
 - What is difficult to do
 - What cannot be done
- Educate the users and management about different kinds of quality:
 - Users: more users, fewer of them experts need to know what they are doing
 - Tools: more tools supporting FMI, we need to support them to improve quality
 - Standard: more power with few versions and small increments in complexity

Continuous effort: Quality

- Quality of implementation
 - More tools adopting the FMI standard will mean new efforts for quality control
 - New standard versions will require updates to
 - FMI Cross Check
 - FMI Compliance Checker
 - Reference FMUs

 - Quality of standard
 - Keep it simple (or we endanger adoption rates)
 - Keep things stable (or we frustrate current users)
 - Add features (or we disappoint users outside the current scope of FMI)
 - Keep it portable (or we will serve only small parts of the simulation community)
-  Conflicting goals we have to balance!

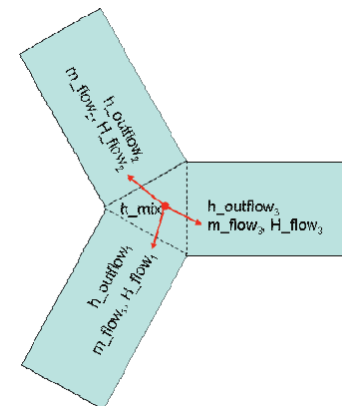
FMI is not magic: License issues

- Exchanging FMUs is great, but...
- In the past, models were mostly caught in the modelling tool could only there be simulated: Tool vendors could rely on a certain number of licenses sold
- Today, one expert can build high-quality simulation components with one modelling tool license and distribute that component to many non-experts running the model in execution platforms of other vendors
- Selling fewer modelling tools might require runtime licenses in FMUs or more expensive export options

- Users prefer FMUs without license trouble
- Some customers are starting to be concerned about FMU proliferation and ask for more FMU protection

FMI is not magic: Numeric challenges (1)

- Decomposing systems into FMUs will increase numeric problems
 - Less chance for system-wide numeric optimizations
 - Might lead to a decrease of performance and solvability
- Selection of interface variables is crucial and needs some insight
 - Algebraic loops might be introduced
 - Exchange of flow variables (force, current, heat flow, ...)
 - Sum of flows has to be zero
 - Difficult to handle for signal based tools
 - Example: three flow variables, all of them are outputs



FMI is not magic: Numeric challenges (2)

- Co-Simulation:
 - Pressure towards Co-Simulation:
 - More tool support for import and export
 - Seemingly simpler usage
 - Co-Simulation introduces time delays
 - Might lead to deviations or instabilities
 - Can be avoided/reduced by sophisticated master algorithms

- Model Exchange:
 - Fewer tools support Model Exchange, since a solver for differential equations is needed
 - Quite hard to couple multiple FMUs because of:
 - Algebraic loops
 - Precise handling of state events

FMI is not magic: Numeric challenges (4)

- Standard solvers:
 - DASSL of tool A differs from DASSL of tool B, even if the same name is used
 - Solvers contain heuristics, which are optimized w.r.t. the models which are most commonly simulated
 - Criteria for acceptance of a solution
 - Criteria for step size selection
 - Criteria for Jacobian updates
 - Detection and location of state events
 - By FMI for Model Exchange import, 2rd party models have to be treated for which the heuristics might not be the optimum
- ➔ Simulation results and computation speed depend on the used solver
- Stability criteria for solution of differential equations are valid for FMU for Model Exchange too!

FMI is not magic: Educating management/users

- Simulation strategies must be realistic:
 - FMI technology is not meant to be used for building libraries of small simulation components
 - Connecting many FMUs will remain a difficult numeric problem tools will need to handle
 - Splitting systems along convenient org-chart lines might not be numerically optimal
 - Simulation responsibilities might cross old, known and trusted sub-system boundaries

- Users still need to be knowledgeable:
 - “Because it compiles it works” has an equivalent: “Because it connects it works”
 - Dangerous materials in standard containers are still dangerous
 - We succeeded in simplifying the handling of simulation components
 - But it still takes great care by system architects to build systems that can be used by non-simulation experts

Summary

- FMI is great – it simplifies many simulation issues

- We must educate:
 - Managers about the limits of the FMI technology
 - Users how to assure simulation quality

- We must assure:
 - Continue FMI Standard development with care to keep the momentum
 - Fast enough to fulfil new needs
 - Keeping stability to not loose current users