Full-scale building models with HVAC and control systems

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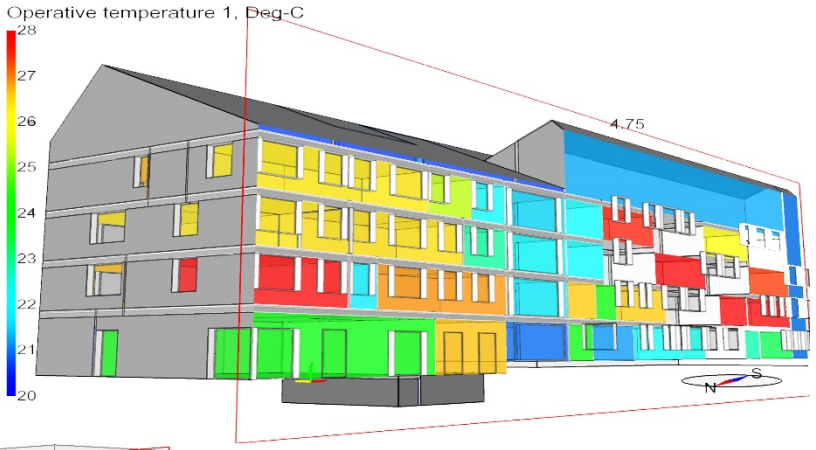

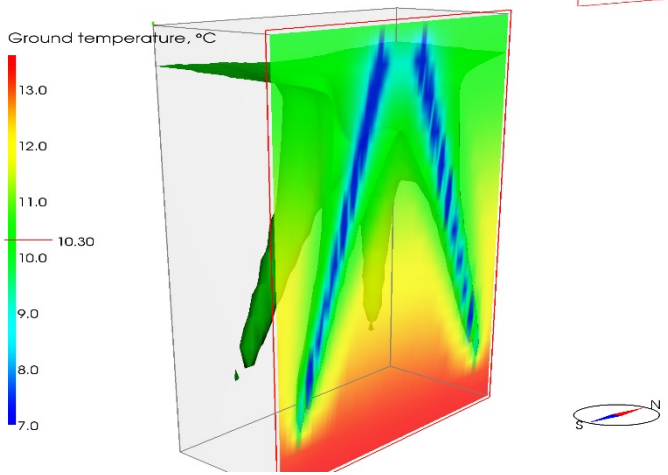

- **EQUA**
- IDA ICE - **EQUA**tion based building simulation
- MIMO controllers in discrete time in IDA
- Demonstrations

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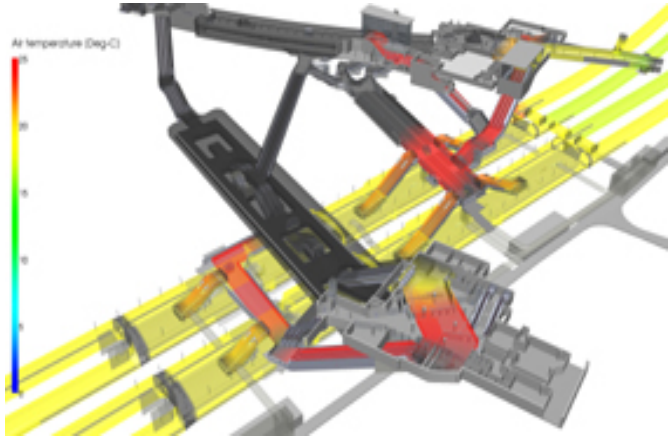

- Late eighties: IDA and NMF (Neutral Model Format) basic R&D at the Swedish Inst. of Appl. Math. and KTH
- IDA based on numerical technique for input-output free DAE modeling with precompiled components
- 1998: IDA Indoor Climate and Energy (IDA ICE) released
- 28 employees, 16 PhD:s (Stockholm, Gothenburg, Helsinki, Zurich, Cologne)
- Products today:
  - IDA Tunnel – environment in rail, road and cable tunnels
  - IDA ICE – leading BPS tool in the Nordic and DACH countries
  - IDA Room/ProClim web– free web simulation – 10 000 users – six languages
  - IDA ICE customizations: Schneider Electric, VELUX, Danfoss, Termodeck, FläktWoods, Halton, Nya Karolinska (project)
  - IDA ICE add-ins: ASHRAE 90.1, bore hole storage, pools, ice rinks

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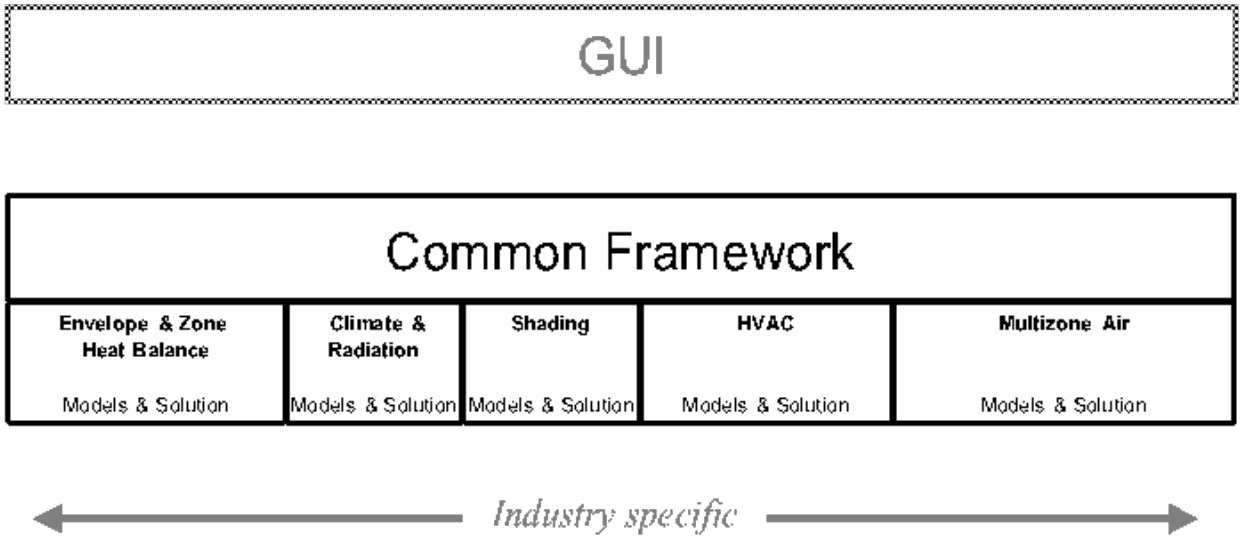
Why DAE based building simulation?

Traditional approach:



- Flexibility
- Reuse
- Transparency

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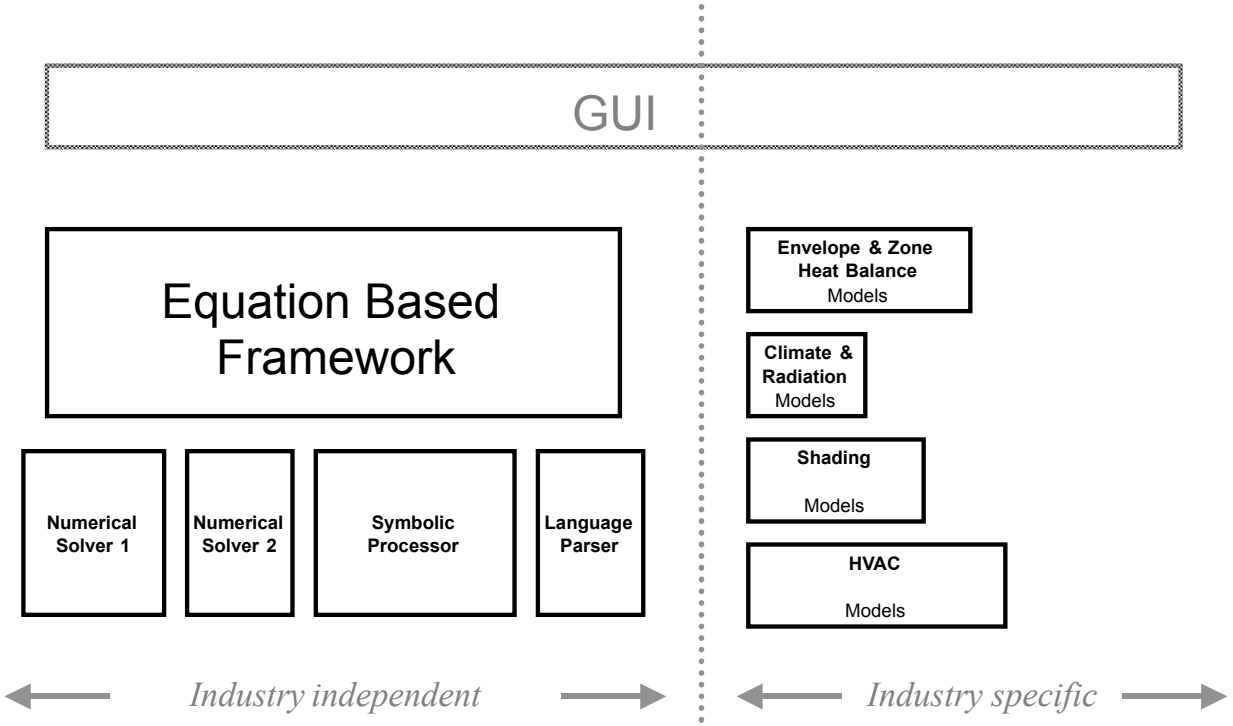
Why DAE based building simulation?

Symbolic equation based approach:



+ Flexibility
+ Reuse
+ Secure model investment
+ Transparency

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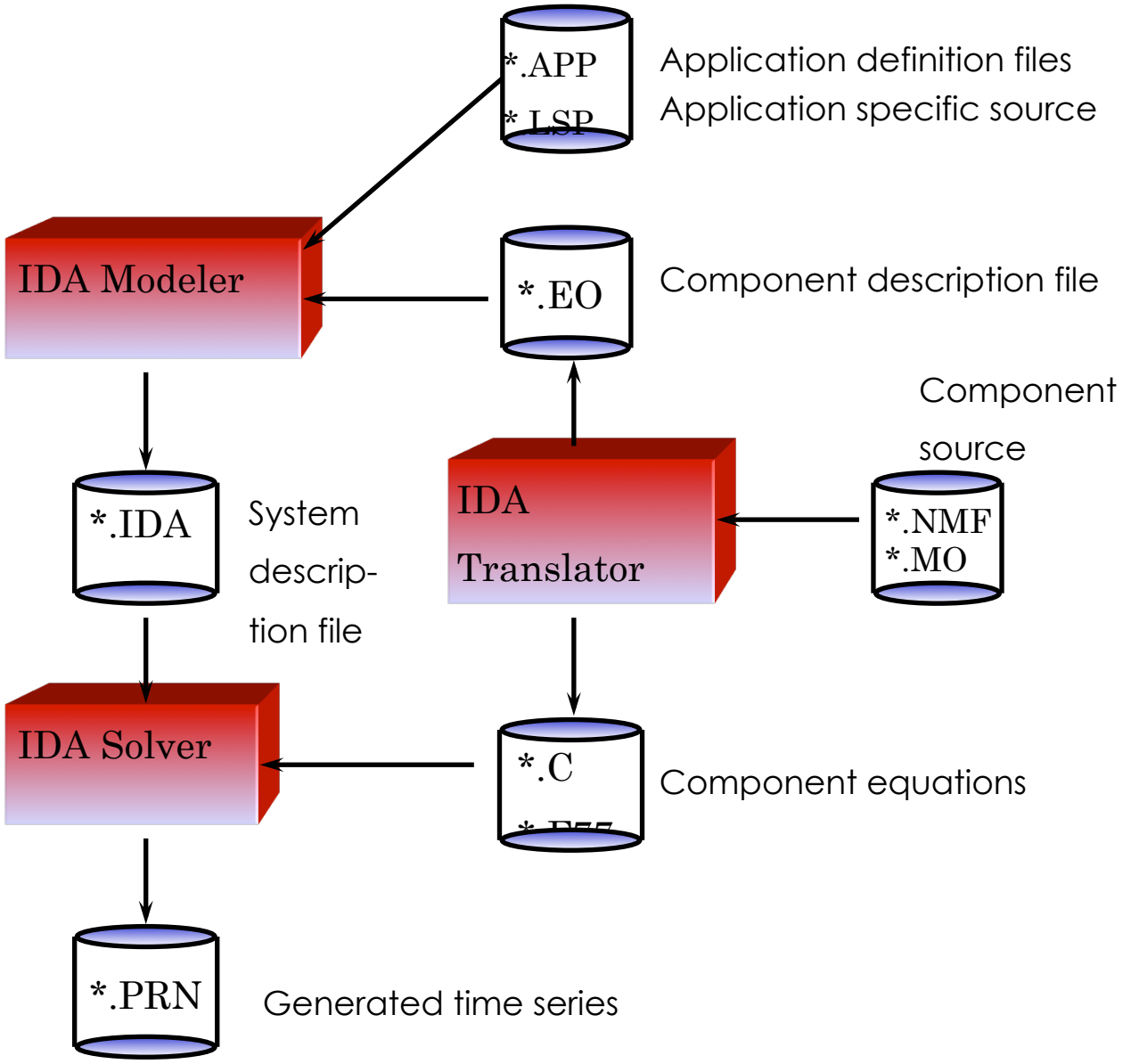
IDA Simulation Environment



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IDA Solver

- Precompiled input-output free component models with dynamical arrays
- Component structure maintained during integration enabling tailored approaches
- MOLCOL implicit multistep methods
- Analytical Jacobians
- Full treatment of events and hysteresis, also in binary foreign functions
- Delays
- A selection of methods for initial value computation: damped Newton, line-search, gradient, homotopy methods
- Third party sparse matrix solvers: SuperLU, MUMPS…
- Parallel version: IDA Star
- Model debugging facilities

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Problem:

- Controller sampling time (execution cycles) are on the order of a second. Simulating a whole building with one second timesteps will take a long time.

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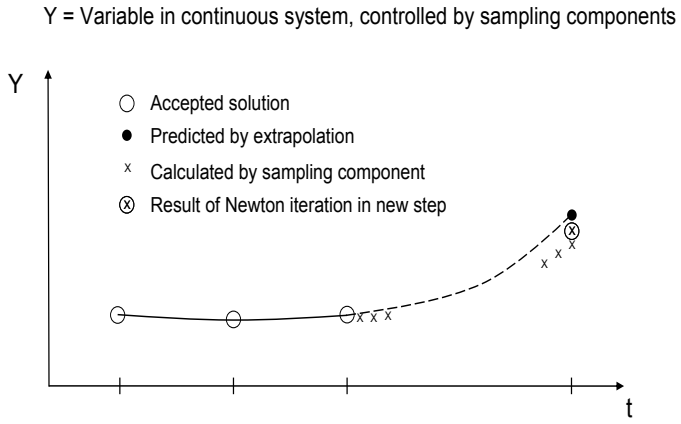
Recent addition to IDA Solver:



- An algorithm that runs the controller and the building with radically different step sizes

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Some results:

	A	B	C
Number of variables	2 187	2 193	2 193
Number of steps			
global successful	6 946	10 540	2 209 400
global total tried	28 035	42 546	2 216 402
sampling successful	0	2 208 000	2 208 000
sampling total tried	0	2 688 241	2 209 543
Integration time [s]	11	21	1 704

A. Continuous controller (function block)

B. Sampling controller with multi-rate integration (new method)

C. Ditto, solve global system each sampling step

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Present state:

- Confronted with some real cases, but not yet widely used
- Solution becomes much more interesting when/if controller code is written in a standardized language (such as IEC 61131-3)

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