Hybrid System Modeling in VDM

MARCEL VERHOEF
CHESS & Radboud University Nijmegen – NL

joint work with **PETER VISSER**
University of Twente – NL

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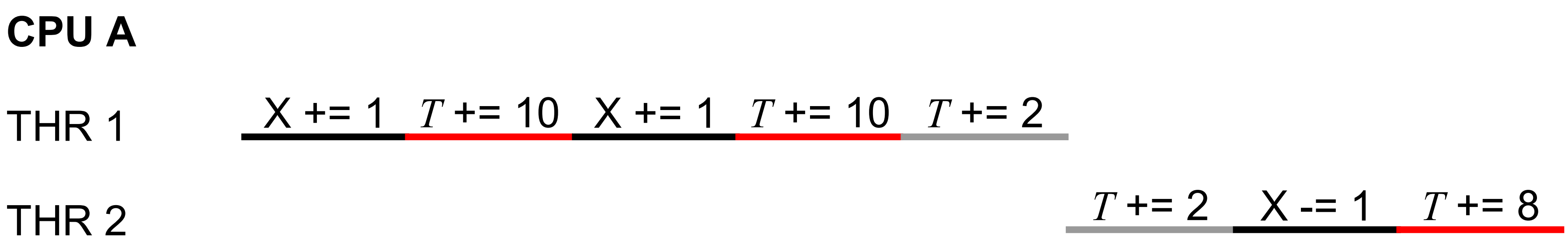
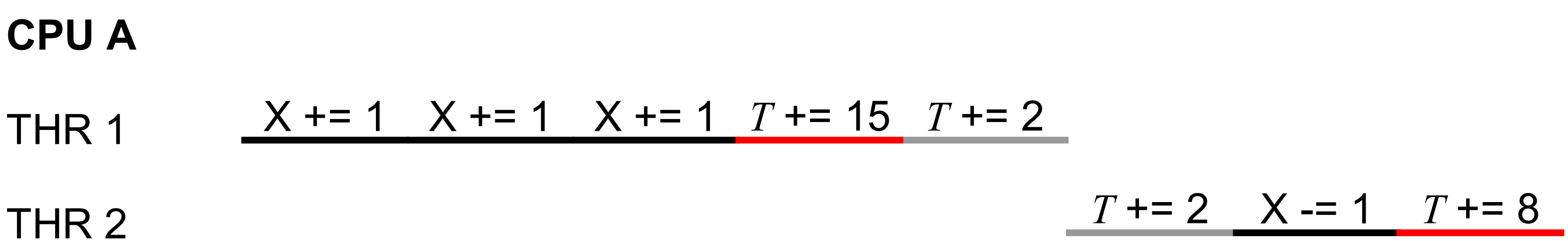
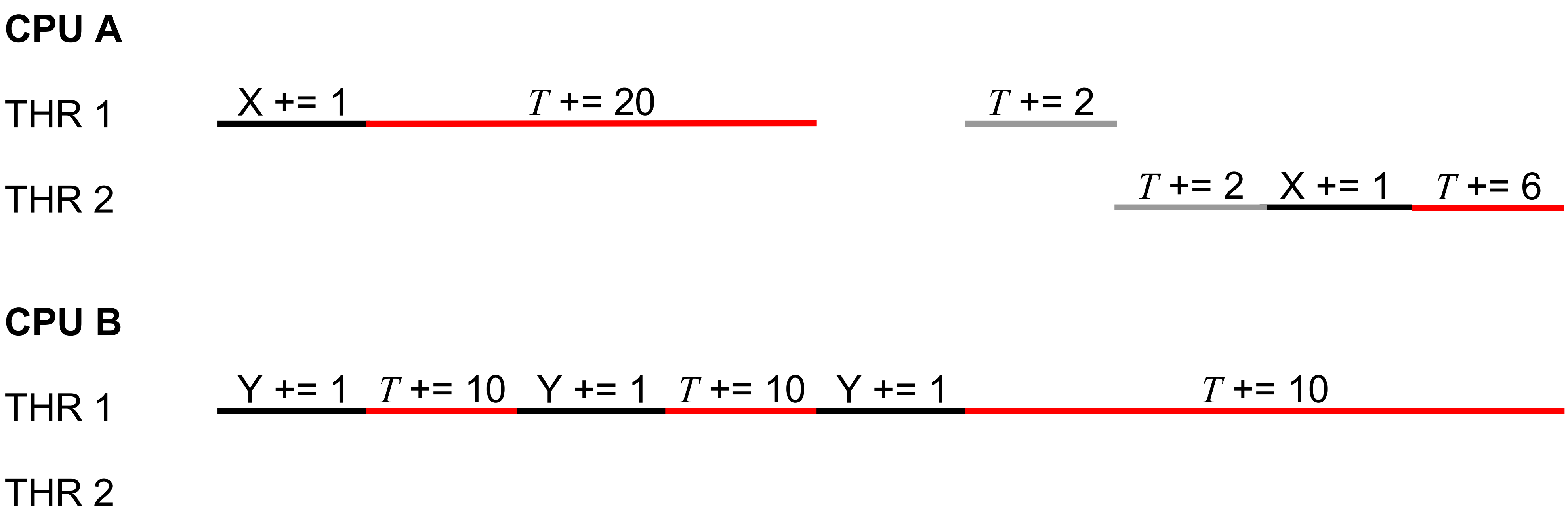
Timed VDM++ dynamic semantics





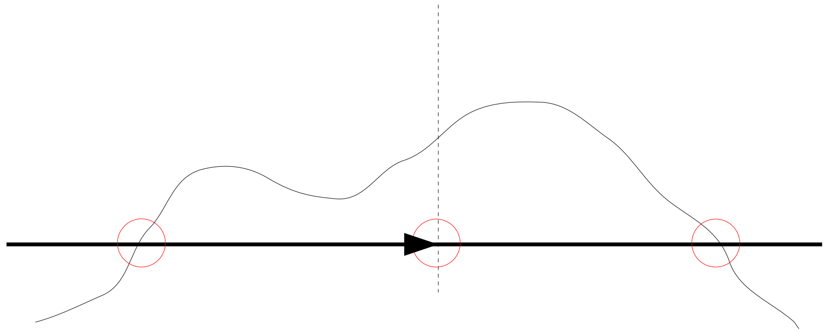
Distributed Timed VDM++ dynamic semantics



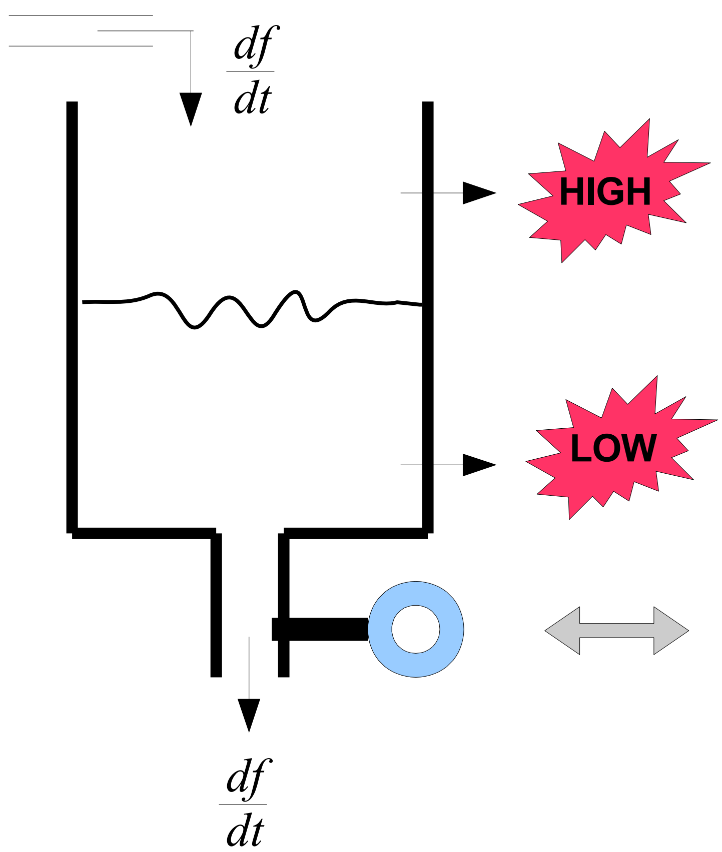
Caveat: BUS activity is dealt with as time steps

Simulation of Continuous Time models

- Sets of differential equations
- Solved numerically using some solver (e.g. Euler)
- State and Time events can be captured
  - state: zero-crossing detection (rising and falling edge)
  - time: proceed to point in the future



Example – Controlling the waterlevel in a tank



class *Controller*
instance variables
  level : **real** := 0.0;
  valve : **bool** := false

operations
  public async *open*: () ==> ()
  open () == valve := **true**;

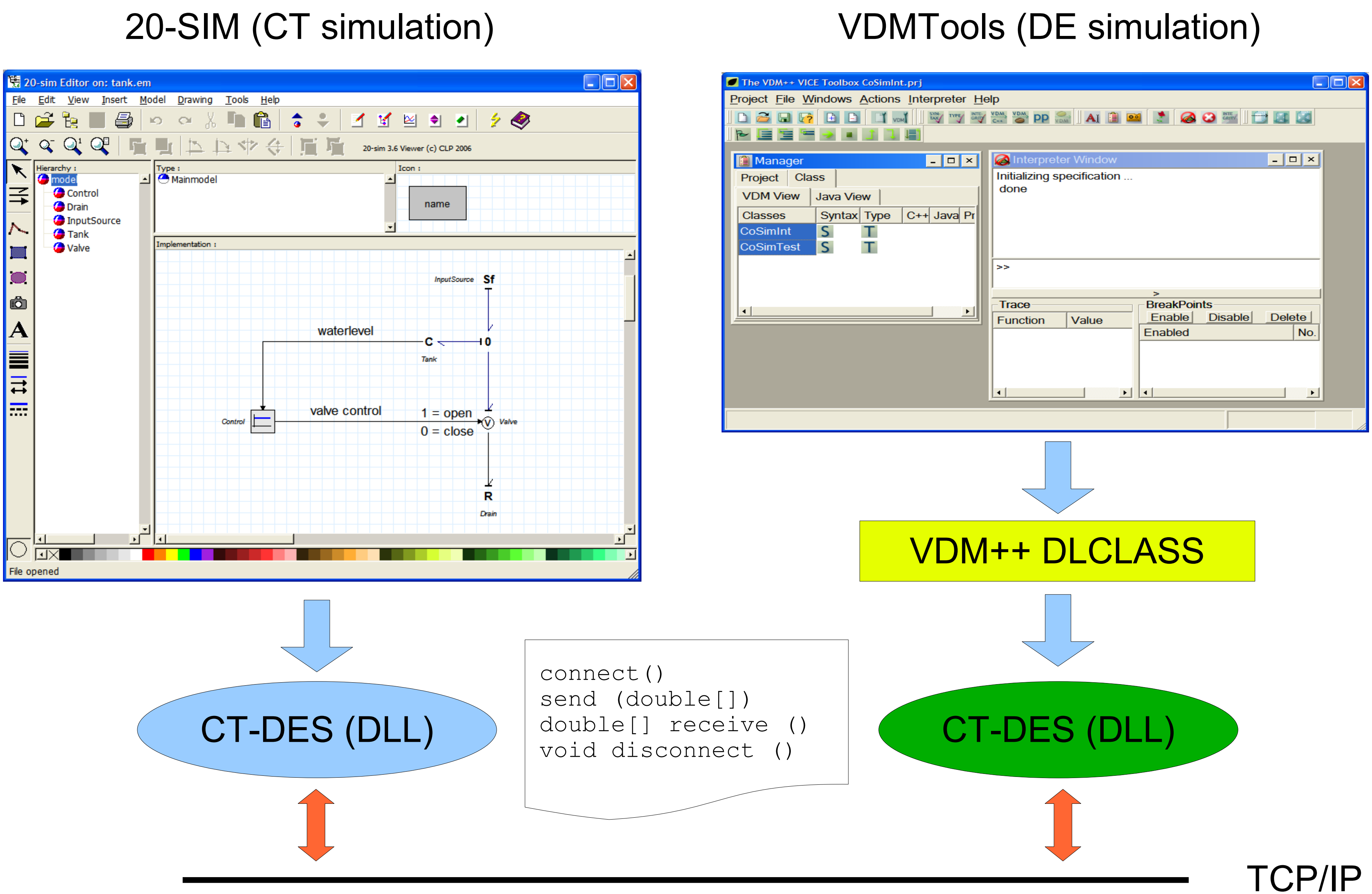
  public async *close*: () ==> ()
  close () == valve := **false**;

  public async *update*: () ==> ()
  update () ==
    if level < 2.0 **then** *close*()
    else if level > 3.0 **then** *open*()

threads
  periodic (1000) (*update*)

end *Controller*

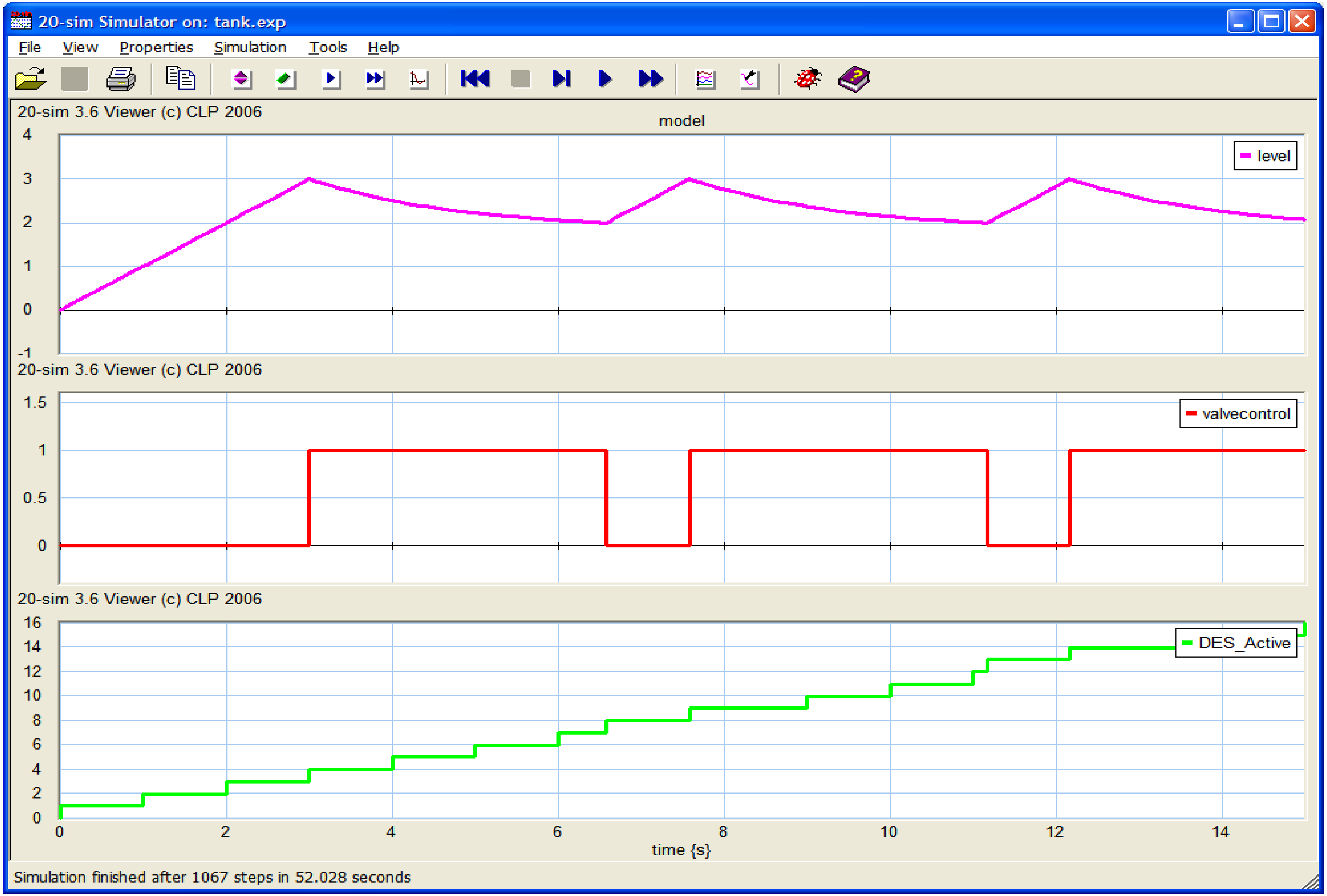
Proof of Concept – Architecture Overview



How is integration achieved?

- DE simulator is in control of time, CT is “slave”
- Perform DE until all CPUs are ready to make time step
- Determine smallest time step (including bus), proceed
- Inform CT solver (shared variables, time step)
- CT solver proceeds until new time is reached
- Inform DES (occurred events, shared variables)
- Events are processed by DES
- Iterate (goto step 2)

Simulation Result



Conclusions and Future Work

- Proof of concept successful
- Integration with new distributed timed VDM++ dynamic semantics is technically feasible
- Larger case study, involving distributed control (alignment unit for a high-volume printer)