

Translating Dataflow Programs to Efficient Hardware: an MPEG-4 Simple Profile Decoder Case Study

Jörn W. Janneck¹, Ian D. Miller¹, Dave B. Parlour¹,
Marco Mattavelli², Christophe Lucarz², Matthieu Wipliez³, Mickaël Raulet³, Ghislain Roquier³

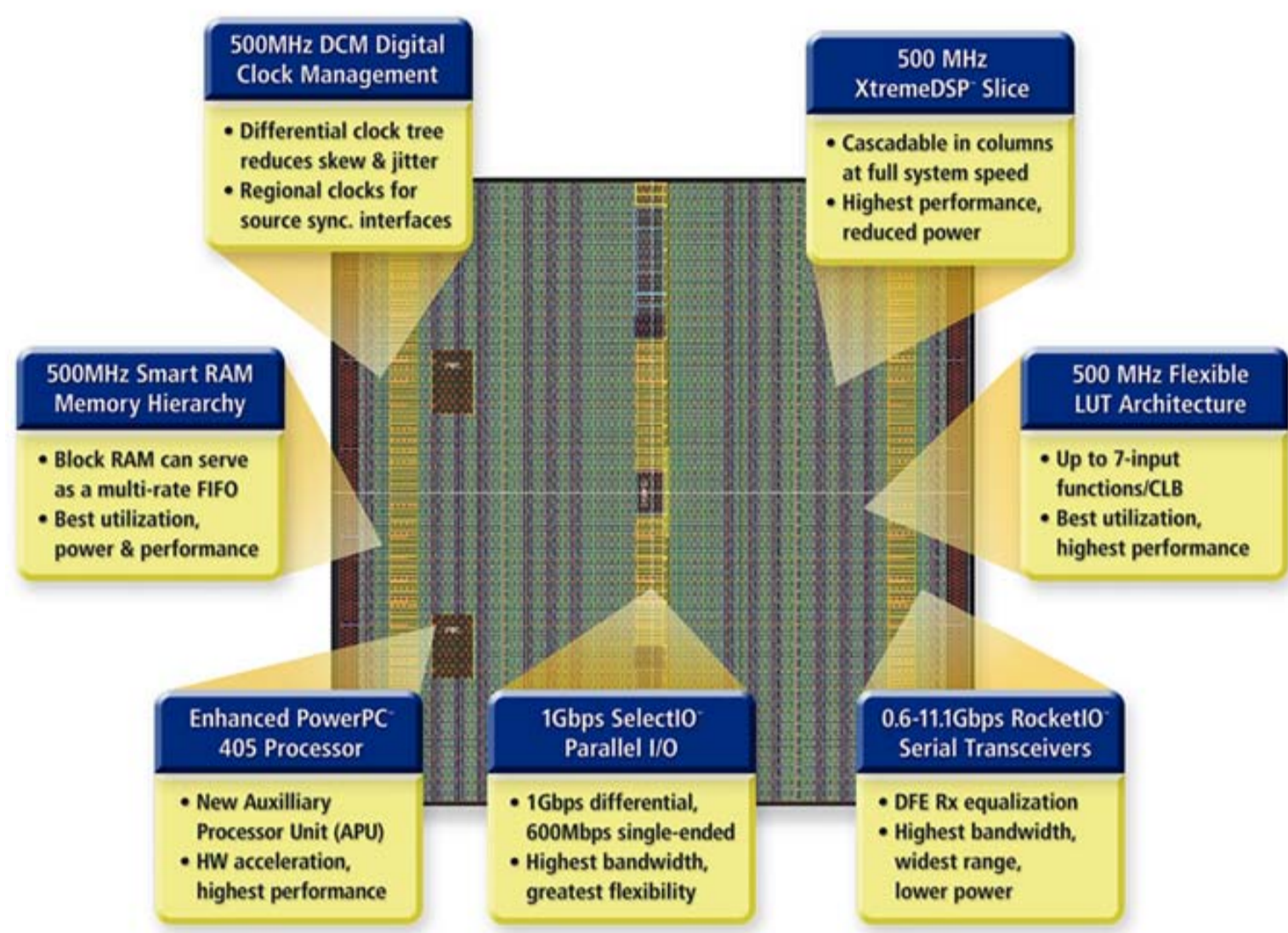
¹ Xilinx, Inc.
San Jose, CA, U.S.A
{jorn.janneck,ian.miller,dave.parlour}@xilinx.com

² Microelectronic Systems Laboratory (GR-LSM)
Ecole Polytechnique Fédérale de Lausanne
CH-1015 Lausanne, Switzerland
{marco.mattavelli,christophe.lucz@epfl.ch

³ IETR, UMR CNRS 6164, Image and Remote Sensing laboratory
Institut National des Sciences Appliquées de Rennes
F-35043 Rennes, France
{mwipliez,mraulet}@insa-rennes.fr

Dataflow programming

Highly parallel computing platform

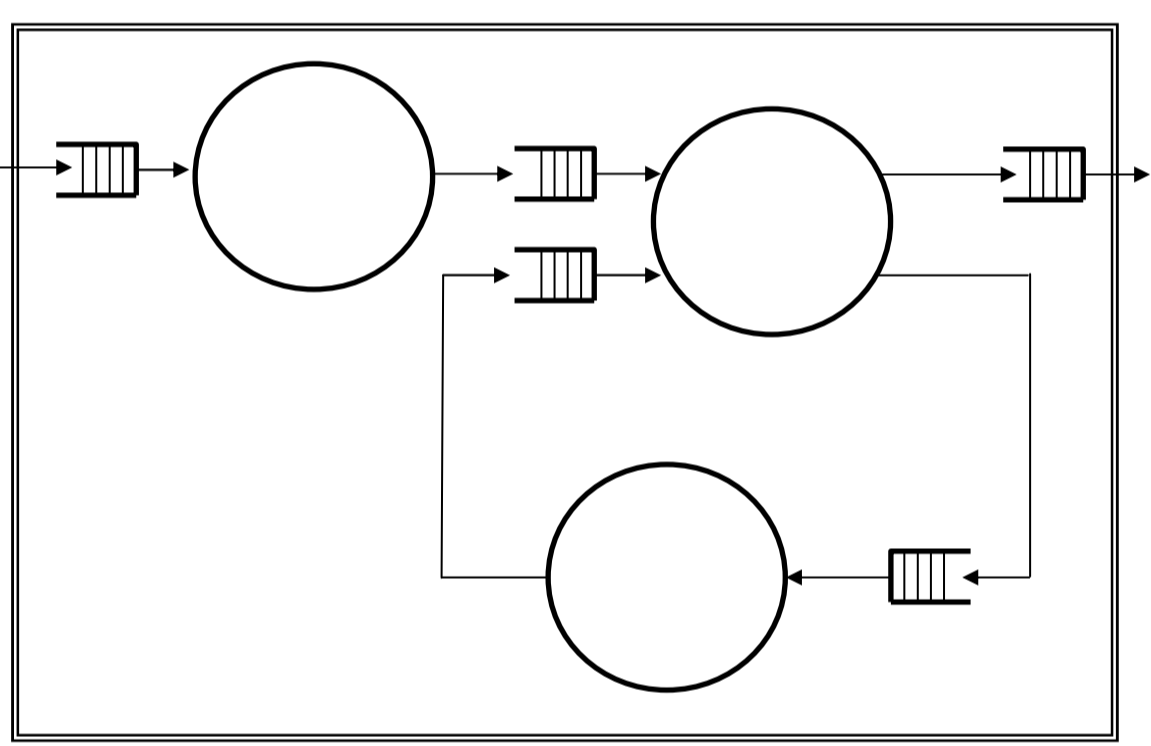


Example:
Xilinx Virtex-4 (XC4VFX140)

- 142k logic cells
- 552 RAMs x 18Kbits each
- 192 DSP ALUs
- 2 PowerPC 405
- 4 Ethernet MACs

Programming model: dataflow with actors

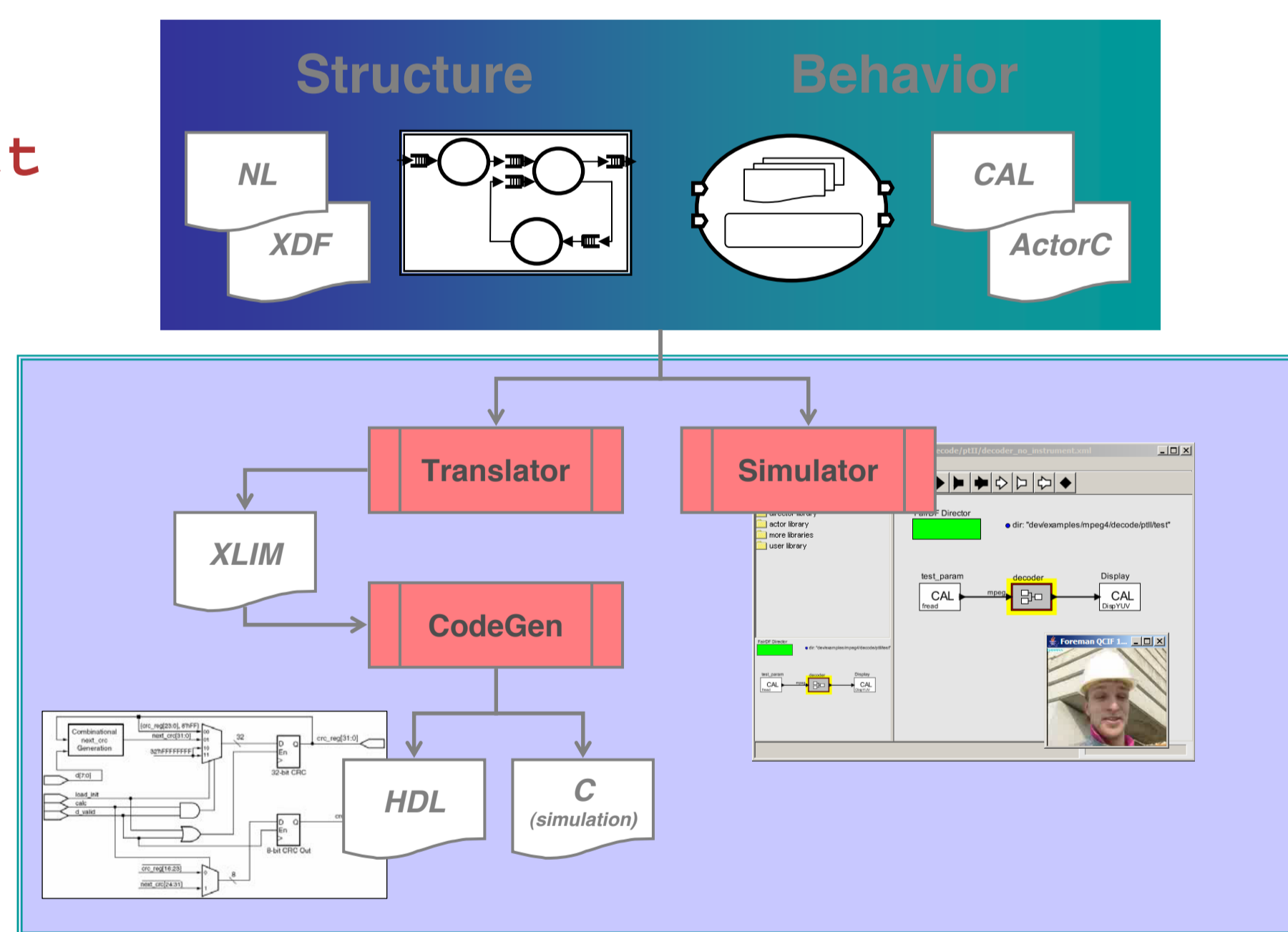
- FIFO connections
- encapsulated state
- atomic state transitions



Dataflow Tools

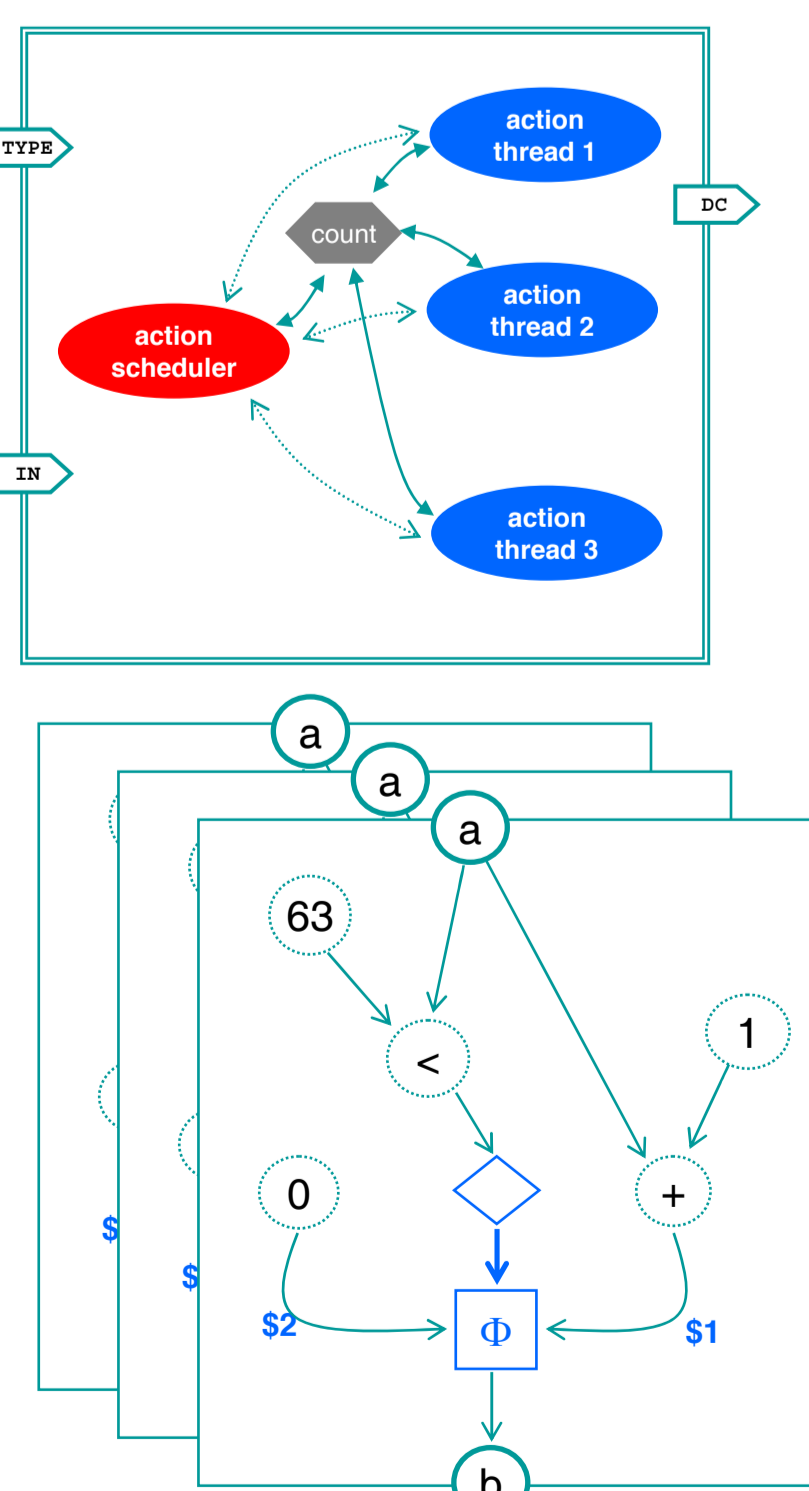
opendf.sourceforge.net

- various input languages e.g. CAL
- untimed simulation
- HDL code generation



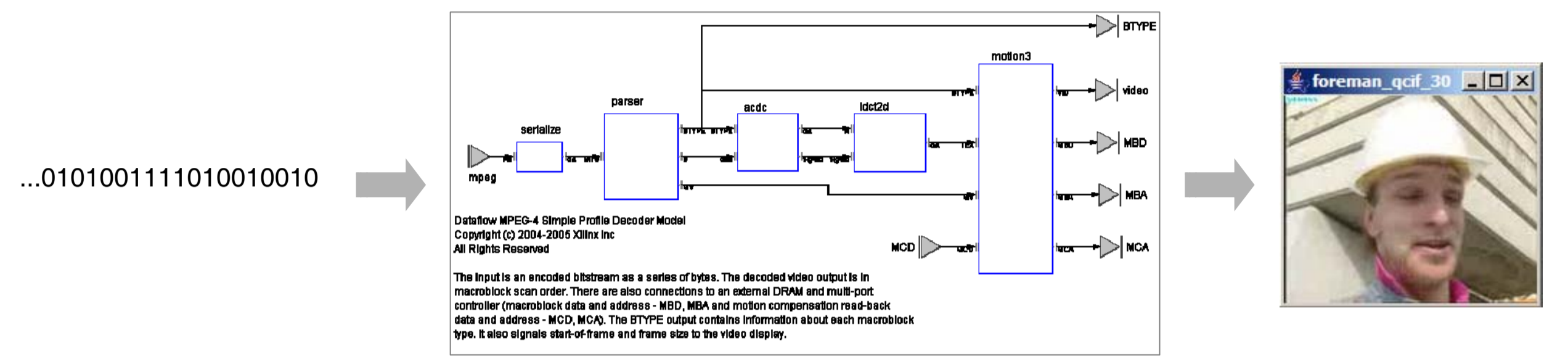
Translation Process

```
actor SendDC (int T_INFER) int TYPE, int IN ==> int DC :
int count := 0;
action TYPE (t), IN (v) ==> DC (v)
guard count = 0, t = 1
do
count := count + 1;
end
action IN (v) ==>
guard count = 0, t = 1
do
count := count + 1;
end
action IN (v) ==>
guard count < 63 then
count := count + 1;
else
count := 0;
end
end
```



1. Actor code split into threads: 1 thread per action +1 thread for the scheduler
2. Each thread represented in SSA form.
3. Produce circuit from SSA form.
4. Optimize data paths (bit-accurate constant prop).
5. Schedule operations when possible.
6. Insert registers where required.

Application: MPEG-4 Simple Profile Decoder



Actors, big and small

CAL actor language

ParseHeaders
1320 lines
(without header comments)

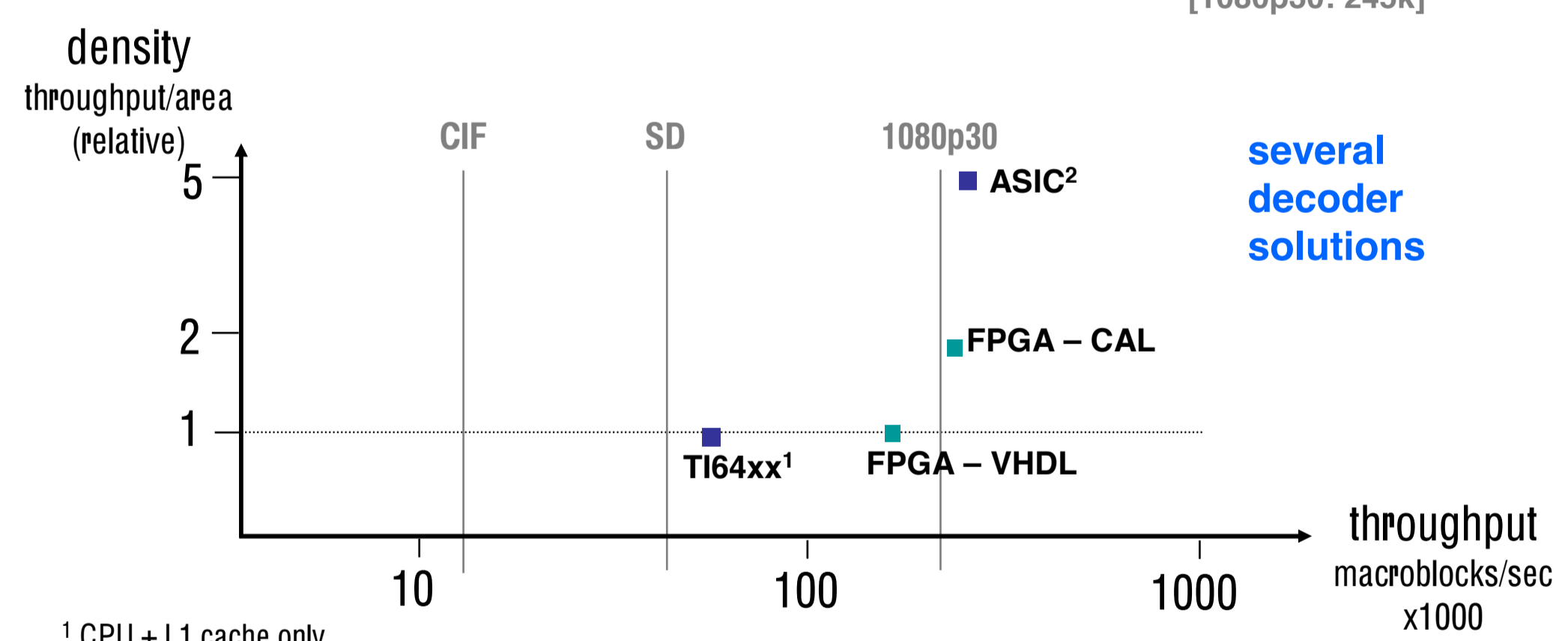
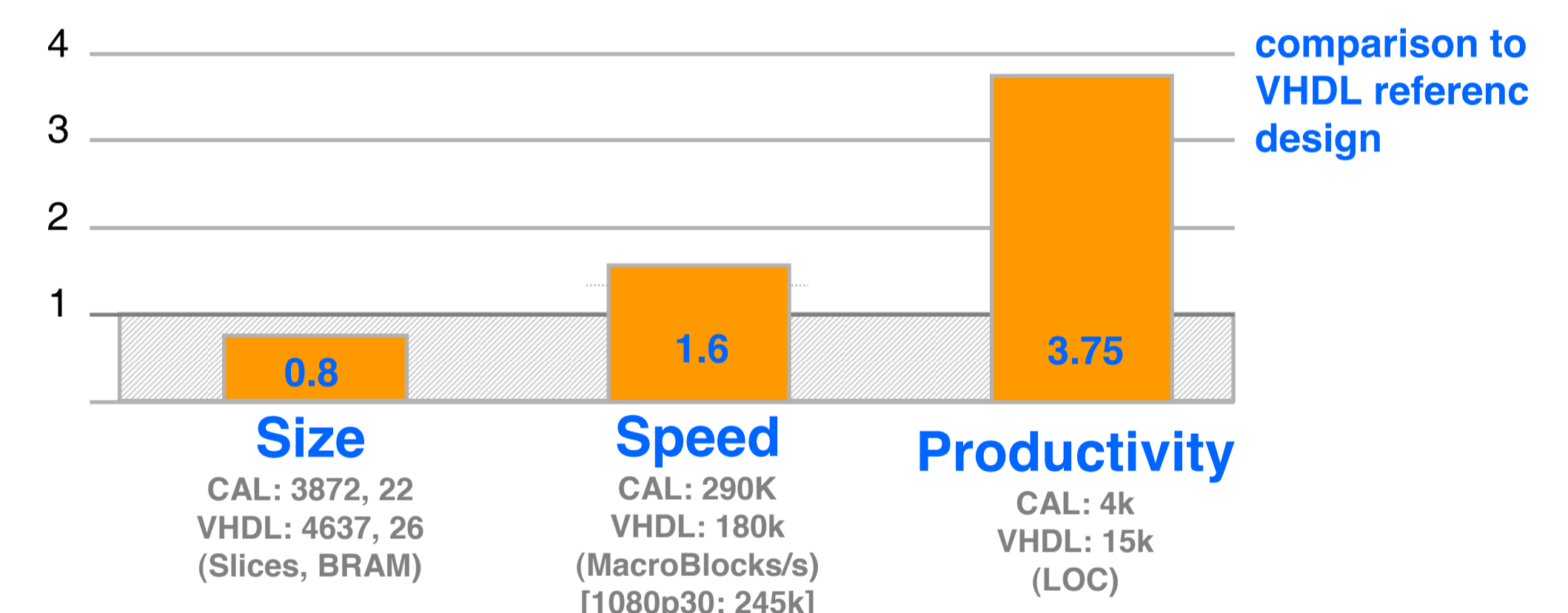
Range of actors

- small compute kernels
- large control-dominated actors

Compare
23 lines
(without header comments)

Hardware Synthesis - Quality of Result

Smaller, faster, and earlier than VHDL reference.



Conclusion

- Parallel platforms require parallel programming models.
- Dataflow is a general and portable way to describe highly parallel computational systems.
- MPEG-4: an at-size, real world application, with a broad spectrum of computational elements.
- All actors built in the CAL actor language, and composed using the NL network language.
- Our tools generate implementations that actually beat the VHDL reference in terms of QoR.
- Any abstraction cost was dwarfed by the ability to quickly iterate over multiple versions of the design.