A Novel Readout Electronics and Reinforcement Learning Platform for Physics Experiments

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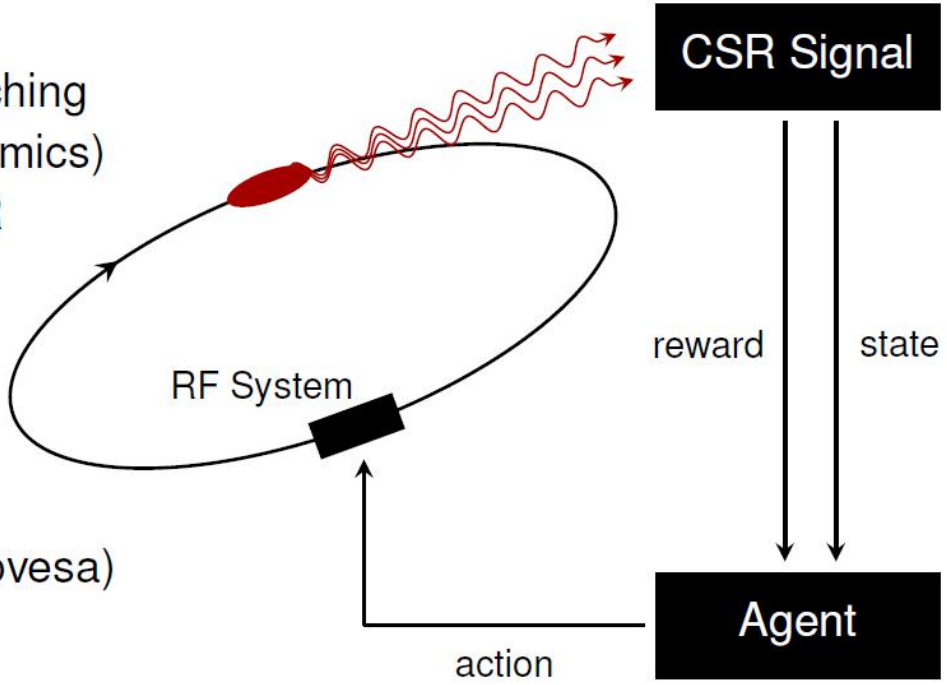
Control of Micro-Bunching using Reinforcement Learning

goal: control micro-bunching
(longitudinal beam dynamics)
to optimize emitted CSR



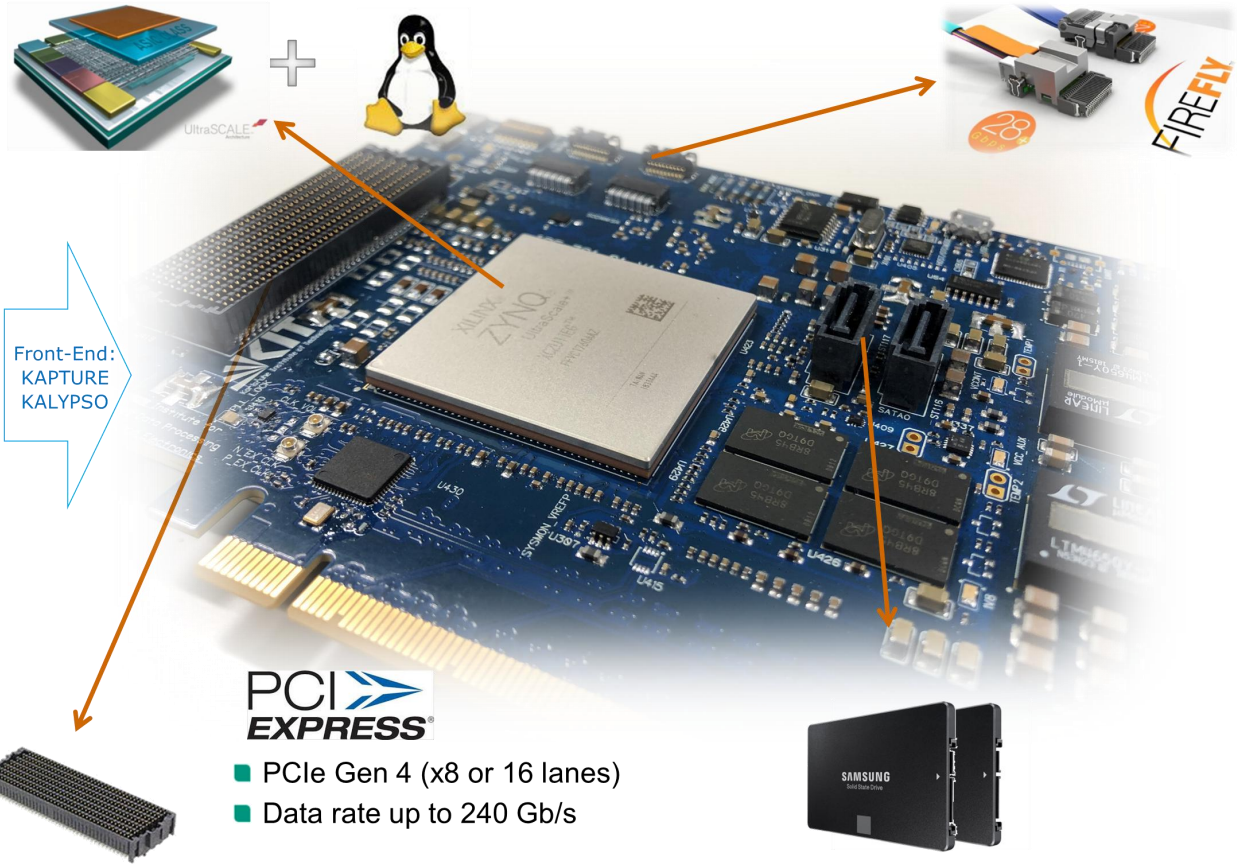
proof of principle:
control in simulation (Inovesa)

implementation:
THz diagnostics (KAPTURE) and RF system at KARA

Courtesy of Tobias Boltz

Novel PCIe ZYNQ Ultrascale+ Data Acquisition Board

- Processor System (ARM): User Applications and Drivers based on Embedded Linux (eg. Yocto)
- Programmable Logic (FPGA): HDL IP Blocks
- Routed on 12 GTY

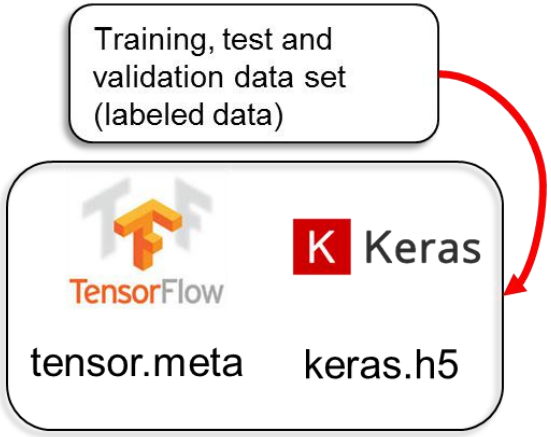


- PCIe Gen 4 (x8 or 16 lanes)
- Data rate up to 240 Gb/s

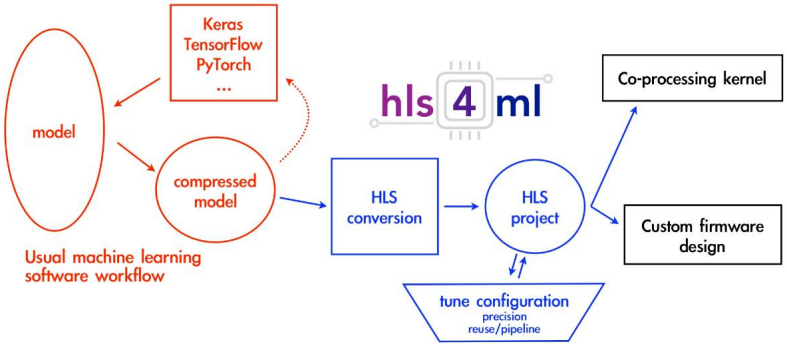
- Extending the total bumber of Gigabit Transceivers to 32
- Compatible with standard FMC

Courtesy of Michele Caselle

The Reinforcement Learning and Supervised Learning Differences on Hardware

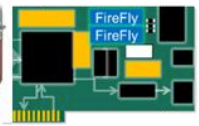


Training Stage

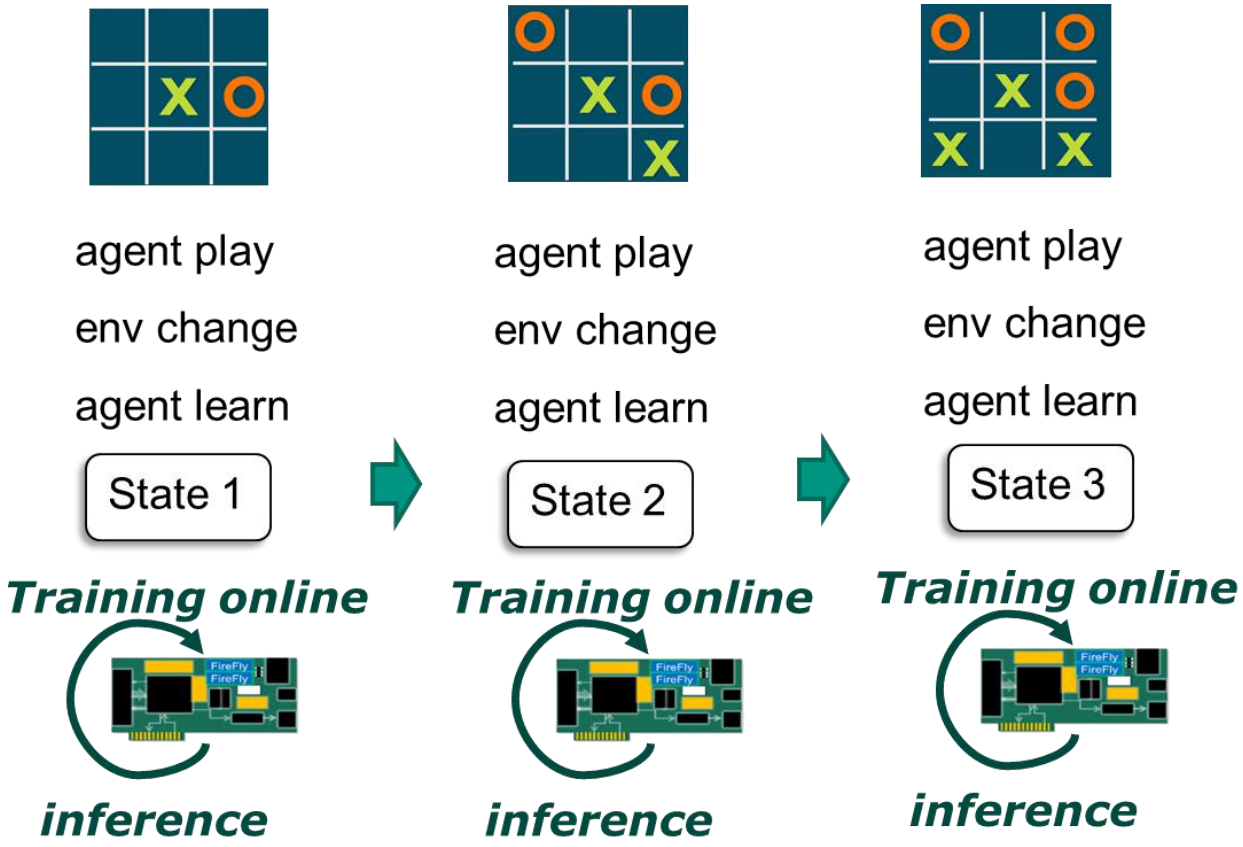


short time it takes, only in
us or hundreds of ***ns*** time scan needs in Hardware

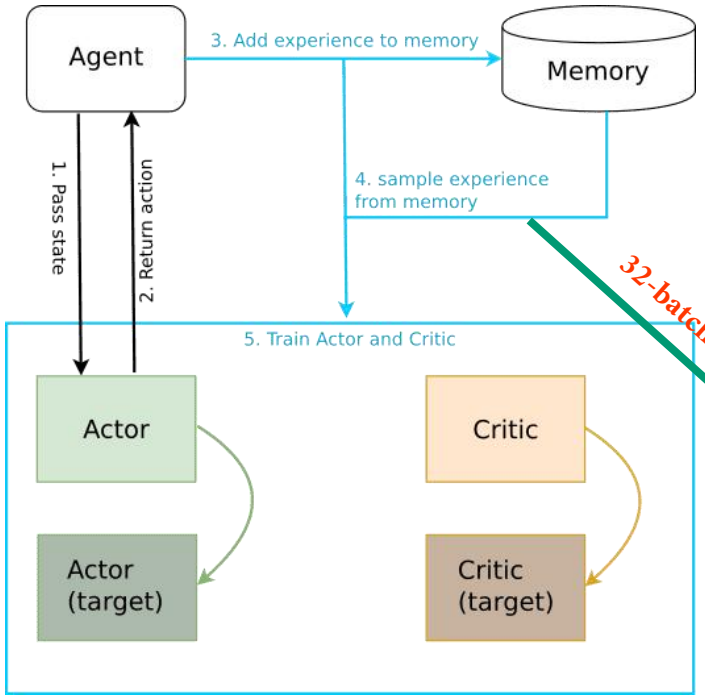
Inference Stage

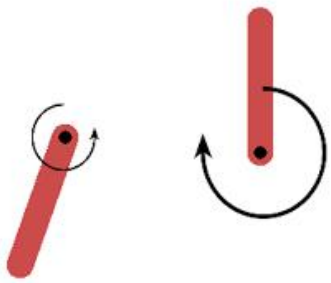


CAT


agent play
env change
agent learn
State 1
Training online
inference
agent play
env change
agent learn
State 2
Training online
inference
agent play
env change
agent learn
State 3
Training online
inference

Control of Micro-Bunching using Reinforcement Learning





A full algorithm transform work is done by C/C++ mix code. A near recent work is continue improves the speed by NEON intrinsic. It shows the a great improvement than Tensorflow on PC. A 32-batch of data on ARM only took around 13.35 us by average, based on this, the PC will take time range of few milli-seconds.

32-batch of data Training Time

TensorFlow on PC	Optimized C on PC	Optimized C on ARM
3145.00 us	91.00 us	13.36 us
3209.00 us	91.00 us	13.35 us
3100.99 us	92.00 us	13.36 us
3260.00 us	91.00 us	13.36 us
3472.00 us	91.00 us	13.37 us
2862.00 us	92.00 us	13.36 us
3338.00 us	91.00 us	13.36 us
2893.99 us	91.00 us	13.35 us
3480.99 us	91.00 us	13.36 us
3760.99 us	91.00 us	13.35 us
3167.00 us	92.00 us	13.36 us
4532.99 us	92.00 us	13.36 us
3822.00 us	91.00 us	13.36 us
2914.99 us	94.00 us	13.35 us
3111.99 us	91.00 us	13.36 us