CFD Acceleration with FPGA

Launching byteLAKE's CFD Suite

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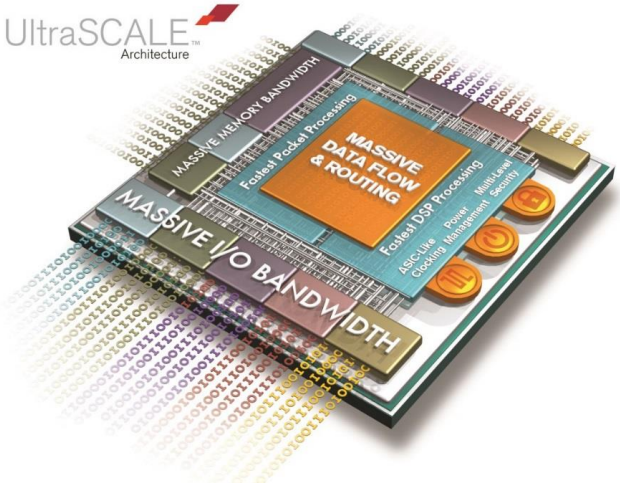
FPGAs – The Ultimate Parallel Processing Device

- No predefined instruction set or underlying architecture
- Developer customizes the architecture to his needs
  - Custom datapaths
  - Custom bit-width
  - Custom memory hierarchies
- Excels at all types of parallelism
  - Deeply pipelined (e.g. Video codecs)
  - Bit manipulations (e.g. AES, SHA)
  - Wide datapath (e.g. DNN)
  - Custom memory hierarchy (e.g: Data analytics)
- Adapts to evolving algorithms and workload needs



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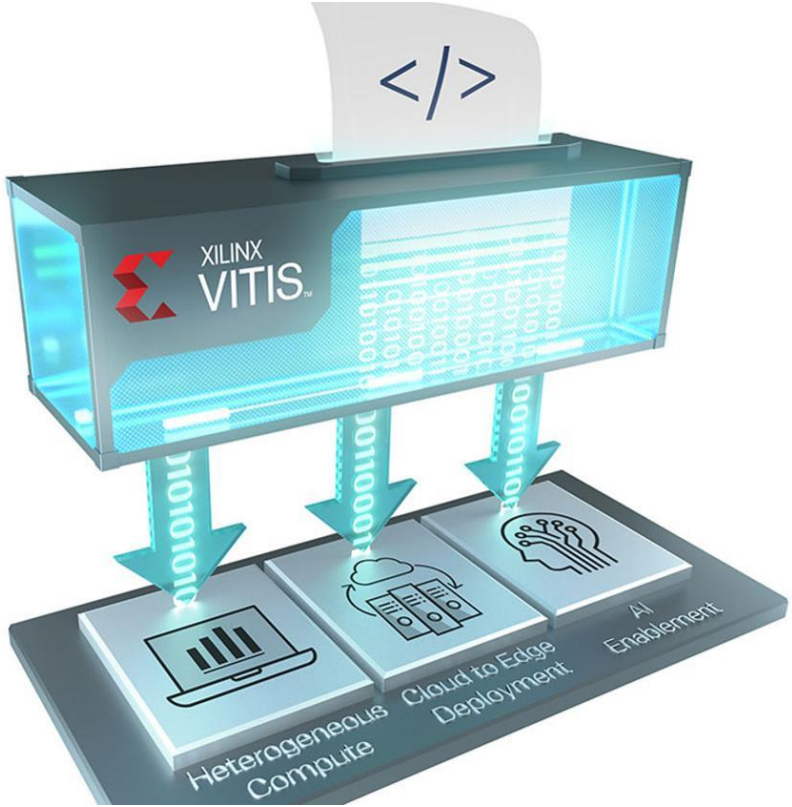
VITIS – Heterogeneous compute development environment



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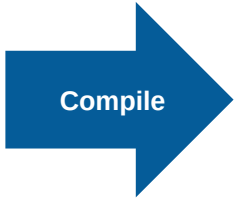
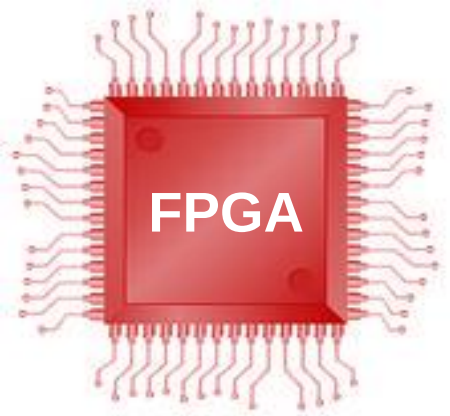
Using C, C++ or OpenCL to Program FPGAs

```
loop_main:for(int j=0;j<NUM_SIMGROUPS;j+=2) {
  loop_share:for(uint k=0;k<NUM_SIMS;k++) {
    loop_parallel:for(int i=0;i<NUM_RNGS;i++) {
      mt_rng[i].BOX_MULLER(&num1[i][k],&num2[i][k],ratio4,ratio3);
      float payoff1 = expf(num1[i][k])-1.0f;
      float payoff2 = expf(num2[i][k])-1.0f;
      if(num1[i][k]>0.0f)
        pCall1[i][k]+= payoff1;
      else
        pPut1[i][k]-=payoff1;
      if(num2[i][k]>0.0f)
        pCall2[i][k]+=payoff2;
      else
        pPut2[i][k]-=payoff2;
    }
  }
}
```





- Xilinx pioneered C to FPGA compilation technology (aka “HLS”) in 2011
- Enables “Software Programmability” of FPGAs
- Includes open source collection of optimized HLS libraries

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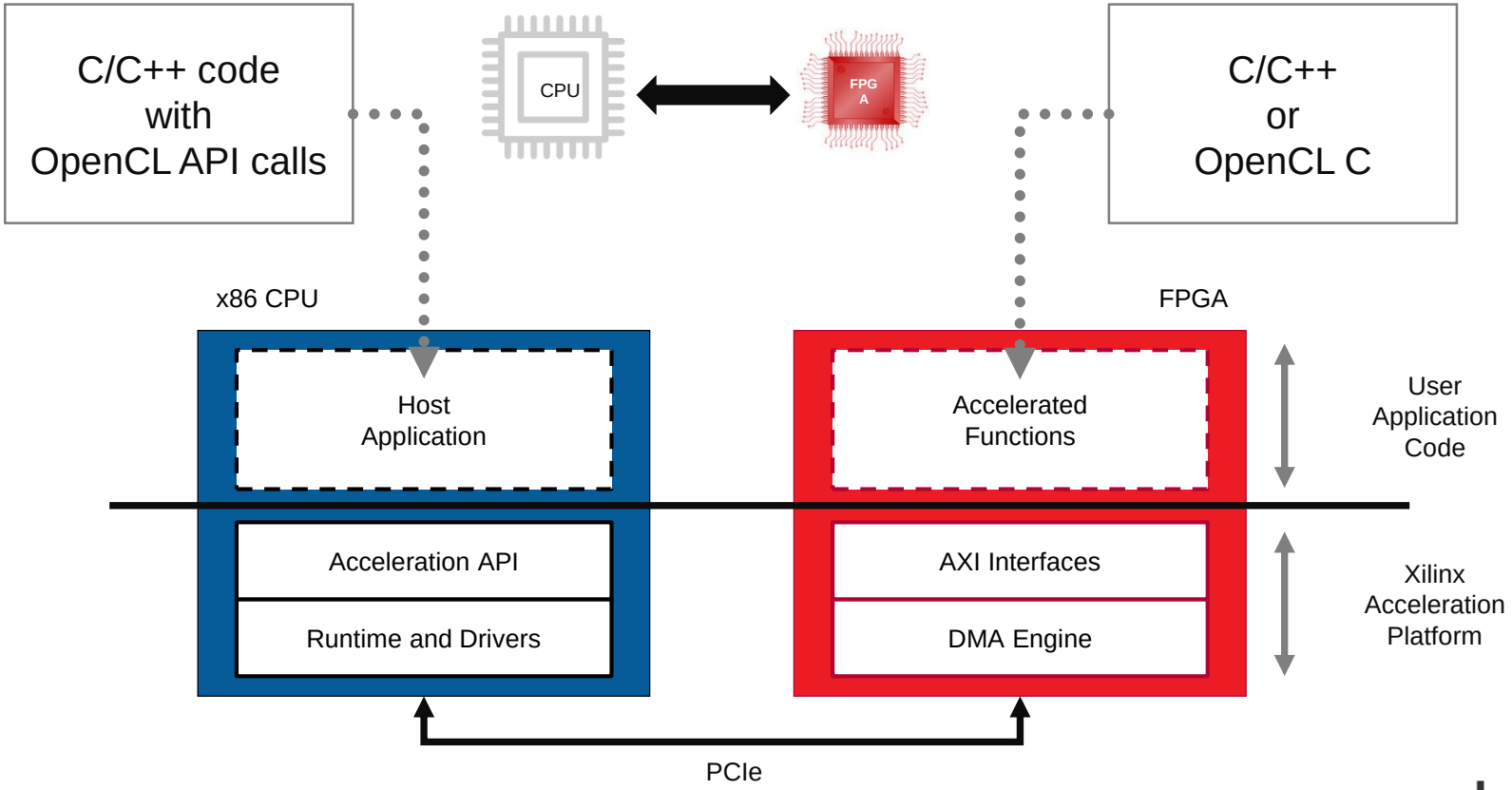
Software Programmability: FPGA Development in C/C++



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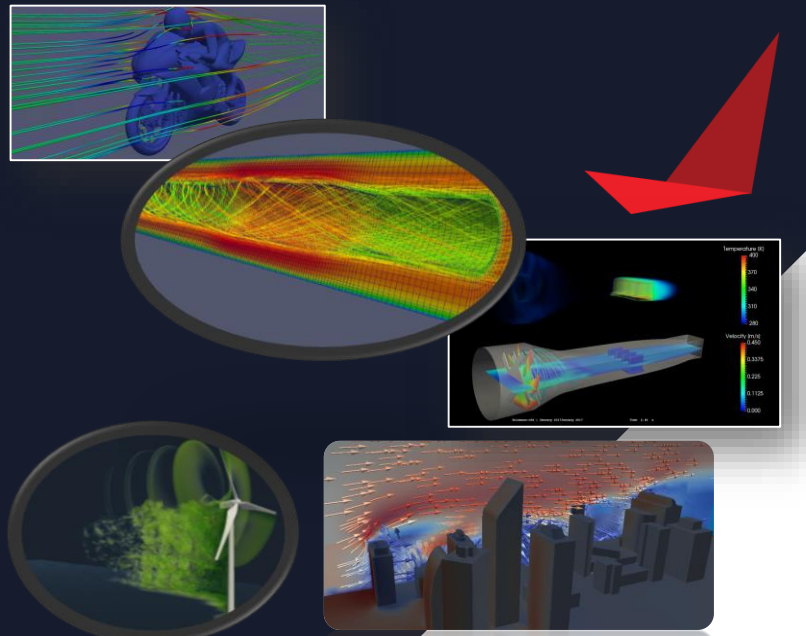
CFD, Computational Fluid Dynamics



- Numerical analysis and algorithms to solve fluid flows problems.
- Model fluids density, velocity, pressure, temperature, and chemical concentrations in relation to time and space.
- Typical applications: weather simulations, aerodynamic characteristics modelling and optimization, flow around buildings simulations etc.

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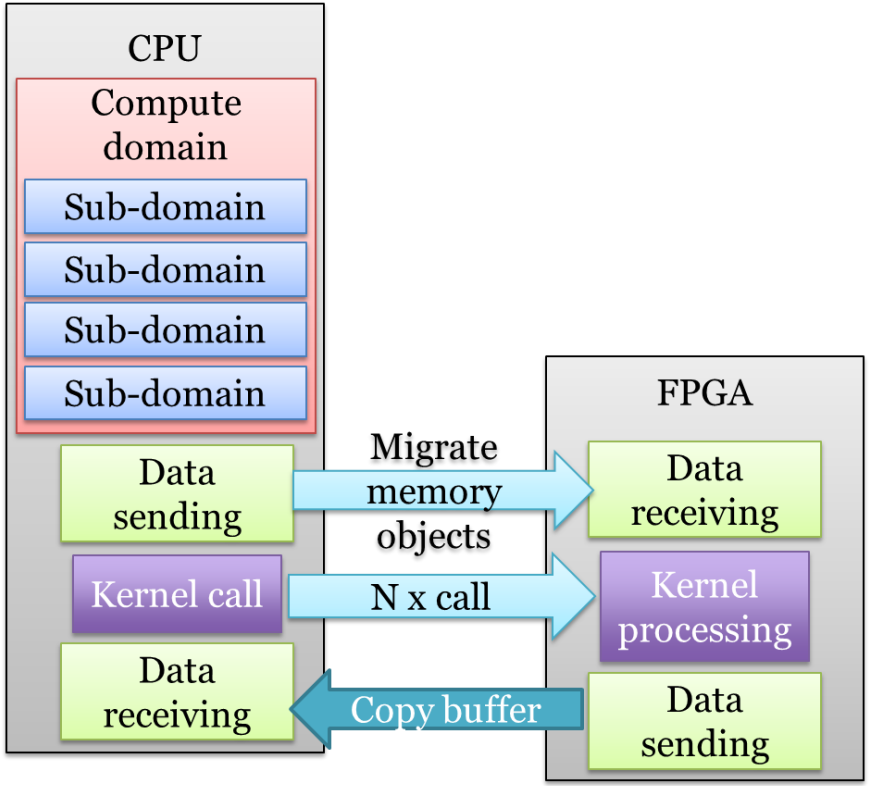
Architecture

- The compute domain is divided into 4 sub-domains
- Host sends data to the FPGA global memory
- Host calls kernel to execute it on FPGA (kernel is called many times)
- Each kernel call represents a single time step
- FPGA sends the output array back to host



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Alveo Optimizations

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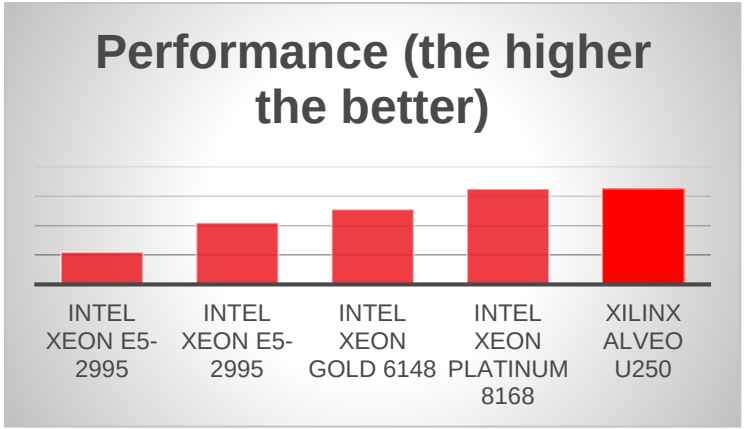
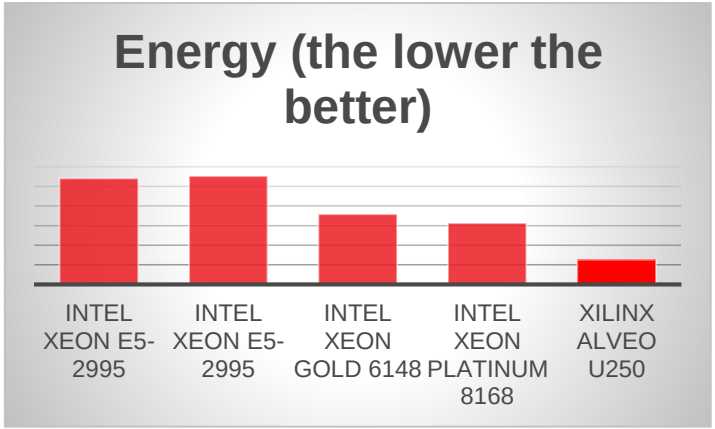
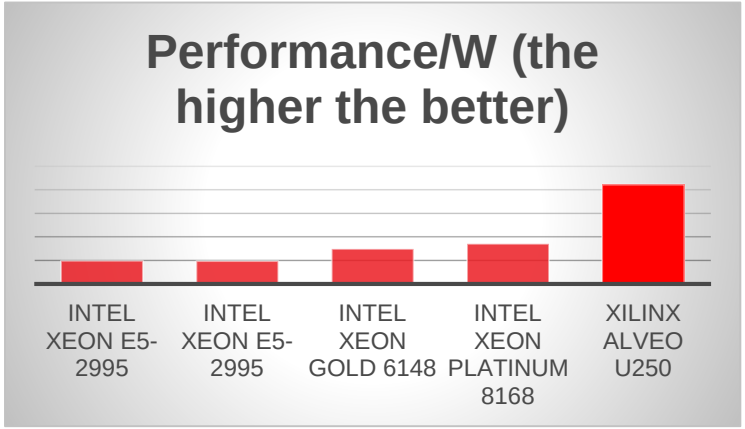
Conclusions







- Up to 4x more performance
- Up to 80% lower energy consumption
- Up to 6x more performance/Watt

Launching byteLAKE's CFD Suite (BCS)

- **Highlights**
  - Collection of Alveo Optimized CFD Workloads
  - Acceleration = Faster Results
  - Green Computing = Improved Efficiency
  - Microservices = Quick Start
  - Excellent TCO = Cost Saving
  - AI Driven Approach

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First Microservices Launching Today

- Advection
- Thomas Algorithm (linear algebra module)

- Low barrier entry
  - Scalable on demand
  - As a Service / Cloud
  - On-premise

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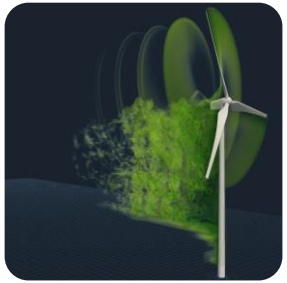
Way Forward

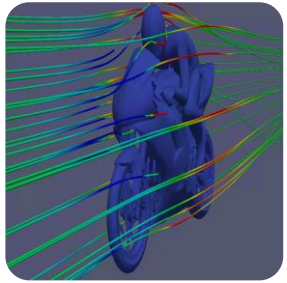
byteLAKE's CFD Suite (GCS)

More Microservices (roadmap)

Green Energy



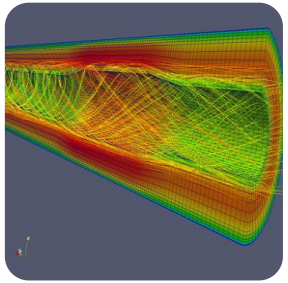
Automotive



Construction

Chemistry

Oil & Gas



Use Case Specific

Highly Optimized

AI Driven

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byteLAKE at SC19

HPC and AI Convergence

- CFD Acceleration with FPGA (workshop)
- byteLAKE's CFD Suite (Alveo optimized, demo)
- Leveraging AI for Reforestation Efforts and AI Training Acceleration (demo)

Booth:

H2RC, 607

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Denver, CO, Colorado Convention Center, Nov 17-21

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Thank You

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