Neural Networks as Function Primitives

Software/Hardware Support with X-FILES/DANA

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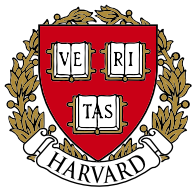
Boston Area Architecture Workshop '16



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- Neural networks and machine learning are everywhere (*again*)
  - Broad use in high tech and big data, e.g., Google's Tensorflow [1]
  - Enable automatic parallelization, e.g., ASC [3]
  - Provide a means for approximate computing, e.g., NPU [2]

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  - Neural networks are a new *functional primitive* useful at various scales of computation [4]

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  - Neural networks are a new *functional primitive* useful at various scales of computation [4]
- With that in mind, we've developed software and hardware for the use of accelerator-backed neural network computation

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X-FILES: Software/Hardware Extensions

Extensions **f**or the **I**ntegration of Machine **L**earning in **E**veryday **S**ystems

- A defined user and supervisor interface for neural networks
- This includes supervisor architectural state (hardware)

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DANA: An Example Multi-Transaction Accelerator

Dynamically **A**llocated **N**eural Network **A**ccelerator

- An accelerator aligning with our multi transaction vision

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Neural Network Transactions

A transaction encapsulates a request by a process to compute the output of a specific neural network for a provided input

Or: A Drop in Accelerator for a RISC-V Microprocessor

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5. User processes can safely throw *transactions* at X-FILES hardware
   - With support for feedforward and learning computation

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Supervisor API

- Establishes sets of processes that can access neural network hardware
- Defines the neural networks that processes are allowed to access
- *More details on the poster!*

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User API

- Works at the level of *transactions*
  - A complete request for access to neural network resources, communication of inputs, processing, and communication of outputs
- Initiating a new transaction
- Writing data
- Reading data

X-FILES/DANA Hardware

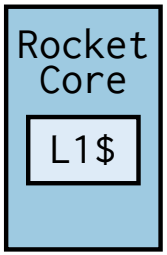

Figure: X-FILES/DANA hardware architecture

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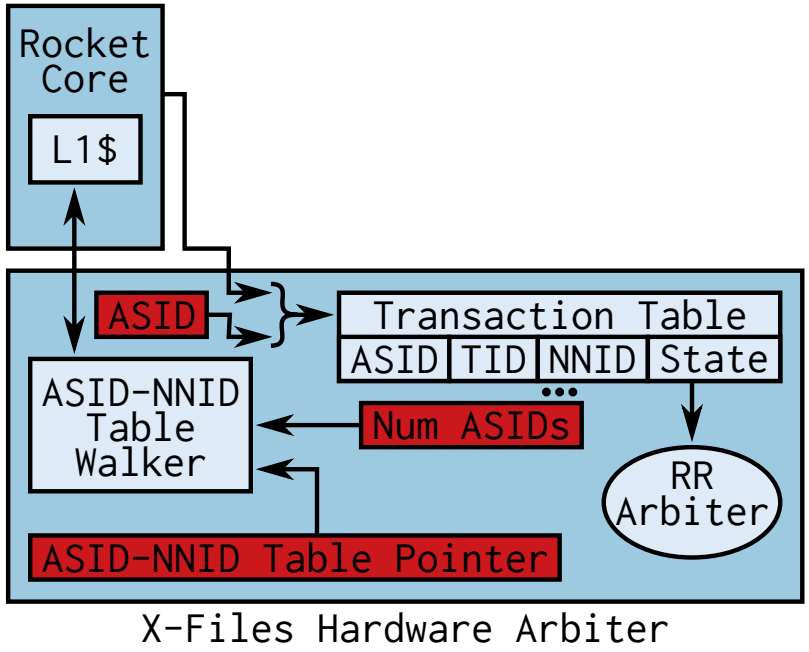

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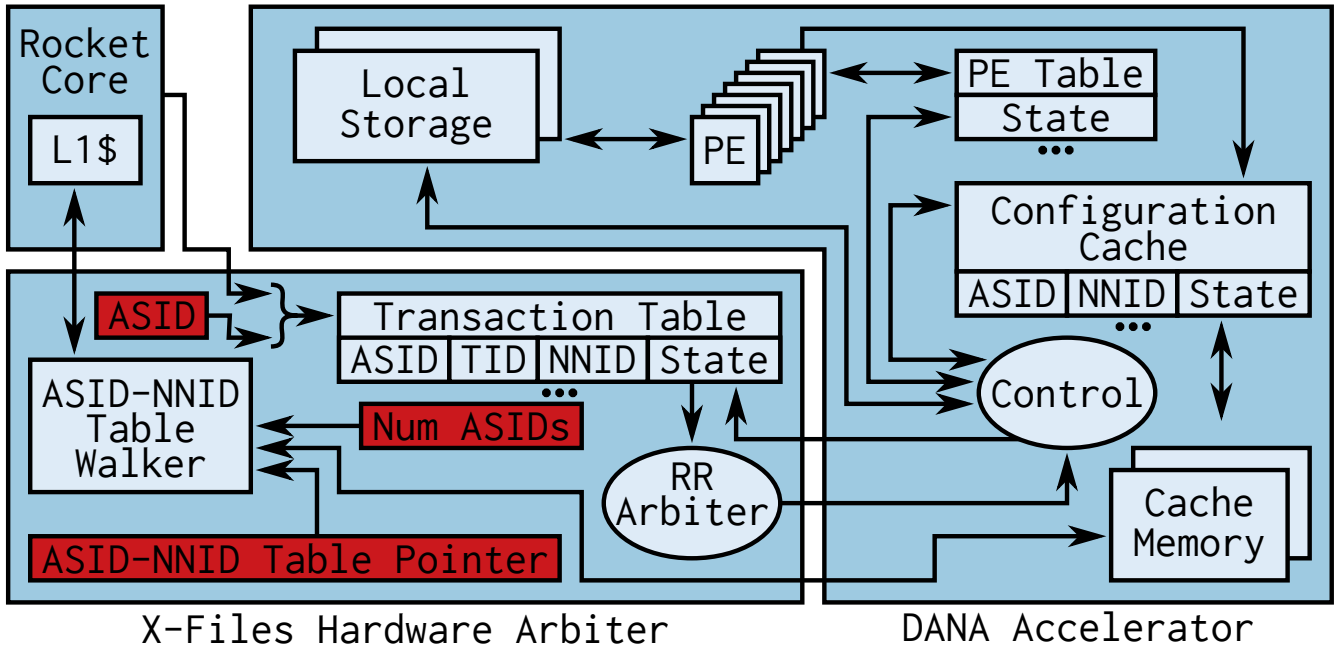

Figure: X-FILES/DANA hardware architecture

Components

- X-FILES Hardware Arbiter maintaining transaction state
- DANA to move transactions towards completion
  - With support for feedforward or learning computation

Open Source Plans

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Remaining Items

- Linux kernel integration
- Support for asynchronous data transfer

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Open Source Availability

- Should be ready by the end of February
- On GitHub: `github.com/bu-icsg/xfiles-dana`

Acknowledgments

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- A NASA Space Technology Research Fellowship
- An NSF Graduate Research Fellowship
- NSF CAREER awards
- A Google Faculty Research Award