Virtual Machine and Bytecode for Optimization on Heterogeneous Systems

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Acknowledgments

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Overview

- Introduction
- Bytecode Design
- Implementation
- Conclusion

Heterogeneous Computing

- Use all hardware components available
  - CPU, GPU, FPGA, DSP

- Increase Performance

- Hardware independent

Heterogeneous Computing Challenges

- Different programming models
- Different combinations of devices
- Little development tool support
  - OpenCL, CUDA
- Developer training

Motivations

- Make heterogeneous computing easier
- Runtime code optimizations
- Platform independence

Annotation

- Provide optimization hints to VM
- Can be disregarded until optimization
- Backwards compatibility
- Two formats
  - Within instructions
  - Annotation file

Annotation Examples

- Immutability
- Escape thread/stack frame
- Generics/Type Erasure
- Specify Device

Popular Virtual Machines

- Java – stack-based
- Dalvik – register-based (16 registers)
- Both have issues

Virtual Machine Design

- Variables
  - 2^{16} per stack frame
  - Type associated with each
  - Annotations
- Class Files
  - Header modeled after Dalvik
  - Annotations

Instruction Format

instruction	var1	var2	var3	var4	var5	var6	annotation

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Instantiates variable *destVar* with the value from *sourceVar*

init-var	*destVar*	*type*	*sourceVar*				annotation

Instantiates variable *destVar* with the value of *literal*

init-var-lit	*destVar*	*type*	*literal* (64 bits)	annotation

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Binary operators on two variables

op-type add sub mul div rem and or xor	*destVar*	*sourceVar1*	*sourceVar2*				annotation

Instruction Format

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Binary operators on two variables

op-type add sub mul div rem and or xor	*destVar*	*sourceVar1*	*sourceVar2*				annotation

Accesses information for the annotation type *annotation* at offset *literal* in the annotation file

annot	*literal* (64 bits)			annotation

Programming Language

Scala

- High-level
- Object oriented/functional
- Compiles to JVM

OpenCL

- Lower-level
- Heterogeneous
- Platform independent (with correct drivers)

GPU Execution

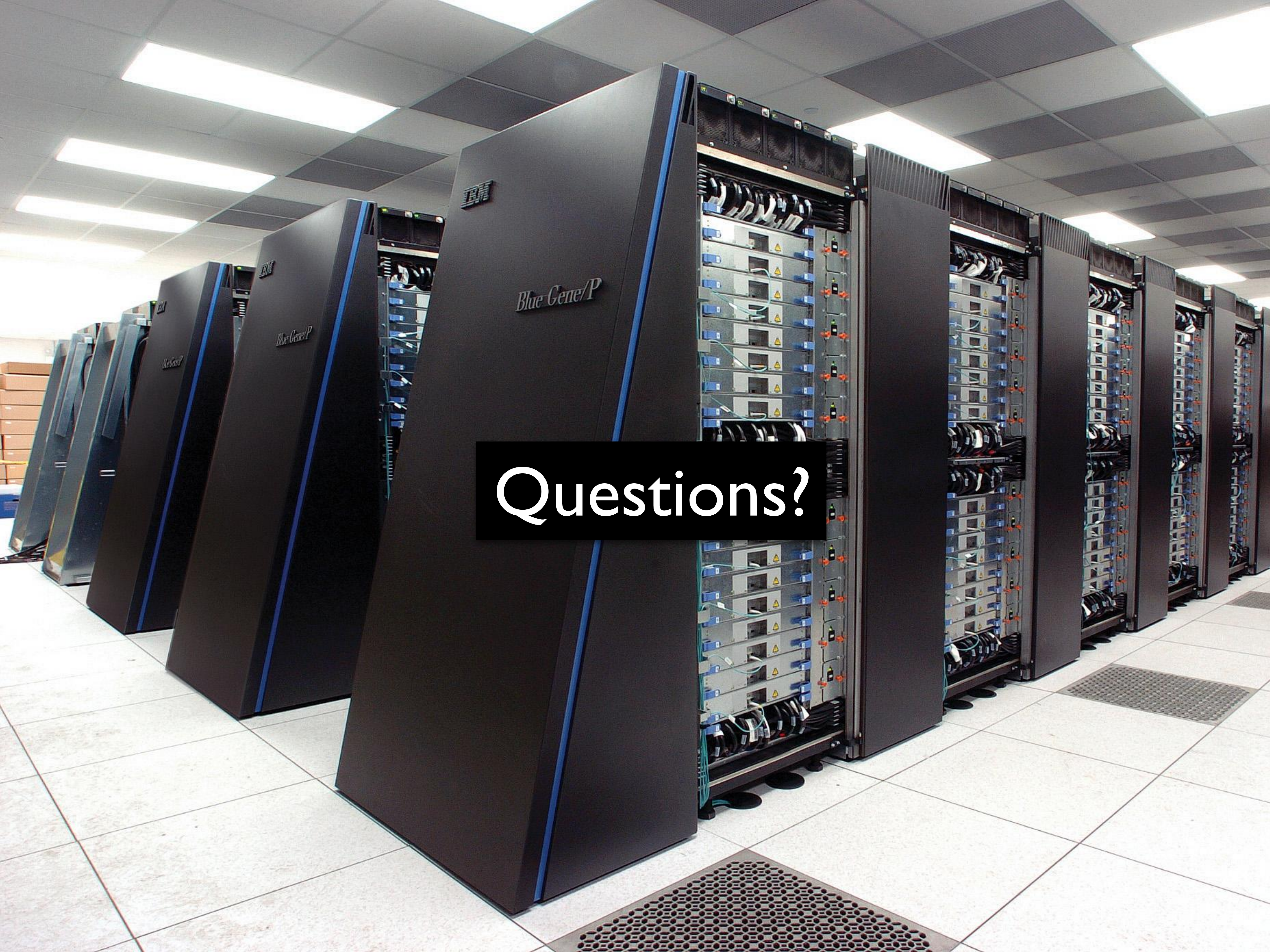
- Uses OpenCL (through JavaCL)
- Compiles bytecode instructions into OpenCL kernel
- Parallelizes over an array of data

Summary

- Heterogeneous computing is hard, but increasingly essential
- Designed bytecode to aid in heterogeneous computing
  - Optimization hints in annotations
  - Platform independent
- Implementation in Scala with OpenCL

Future research

- Design more annotations
- Implement more annotations
- Develop lower level interpreter/JIT compiler
- Explore program analysis techniques



Questions?