Building and maintaining an applied research group:
A retrospective of the Beehive Lab

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Bee**hive lab**

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https://github.com/beehive-lab

# Brief History…and Motivation

Passionate about Virtual Machines and HW/SW co-design

- PhD in Distributed Software Transactional Memory: 2011
  - Java Virtual Machines and concurrency models
- Senior Research Scientist at Intel Labs: 2013
  - Hardware design and performance engineering
- Principal Member of Technical Staff at Oracle: 2014
  - Graal compiler and memory management
- Academic Staff at University of Manchester: 2015 – Today
  - Heterogeneous computing, Systems software
- Chief Engineer at Pierer Innovation/KTM: 2020-Today
  - Automotive, embedded software, research innovation
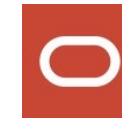
Building research teams

Conceptualization

- Too many questions that seek answers:
  - Applied or blue-sky research
- Research question generation: What? Why? How?
- Do people care?
  - Literature review
  - Funding calls
  - Discussions with colleagues
  - Strategic Initiatives
- Shape ideas, positioning and forming alliances

Building research teams

Towards genesis

1. Find call
2. Form consortium
3. Write grant proposal
4. Fail
5. Reflect on feedback, goto 2

1. **Excellence** #@REL-EVA-RE@#

Excellence – aspects to be taken into account.
– Clarity and pertinence of the project's objectives, and the extent to which the proposed

Evaluation Result

Total score: 8.50 (Threshold: 10)

Criterion 1 - Excellence

Score: **2.00** (Threshold: 3 / 5.00 , Weight: -)

The following aspects will be taken into account, to the extent that the proposed work corresponds to the description in the work programme:
- Clarity and pertinence of the project's objectives, and the extent to which the proposed work is ambitious and goes beyond the state of the art.
- Soundness of the proposed methodology, including the underlying concepts, models, assumptions, inter-disciplinary approaches, appropriate consideration of the gender dimension in research and innovation content, and the quality of open science practices, including sharing and management of research outputs and engagement of citizens, civil society and end users where appropriate.

• Describe where the proposed work is positioned in terms of R&I maturity (i.e. where it is situated in the spectrum from 'idea to application', or from 'lab to market'). Where applicable, provide an indication of the Technology Readiness Level, if possible distinguishing the start and by the end of the project.

⚠ *Please bear in mind that advances beyond the state of the art must be interpreted in the light of the positioning of the project. Expectations will not be the same for RIAs at lower TRL, compared with Innovation Actions at high TRLs.*

#§PRJ-OBJ-PO§#

1.2   Methodology #@COM-MET-CM@# #@COM-PLE-CP@# *[e.g. 14 pages]*

• Describe and explain the overall methodology, including the concepts, models and assumptions that underpin your work. Explain how this will enable you to deliver your project's objectives. Refer to any important challenges you may have identified in the chosen methodology and how you intend to overcome them. *[e.g. 10 pages]*

⚠ *This section should be presented as a narrative. The detailed tasks and work packages are described below under 'Implementation'.*

⚠ *Where relevant, include how the project methodology complies with the 'do no significant harm' principle as per Article 17 of Regulation (EU) No 2020/852 on the establishment of a framework to*

Building research teams

Success will come through grinding

- First successful grant is always emotional
  - ~ avg. after 10 failed attempts (>500 written pages)
- New start, new challenges
  - Recruiting
  - Technical/Project Management
  - Principal Investigator = Tech Lead, Research Lead, HR, Admin…
- Start thinking of next grant: create a pipeline

Building research teams

Research teams are the key to success

- Research staff and students are they key to success
- Long term commitment is rare and challenging
  - Non-competitive academic salaries
  - Job insecurity due to project contracts
  - *Typically* lack of personal development due to academic policies
- Enable researchers to grow and pursue own interests
  - Research is collaborative and multifaceted
  - People grow, research ideas mature
  - Sometimes…tough decisions need to be made

Beehive Lab: Introspection

- Founded in 2014
- Focus on HW/SW Co-design
    - Virtual Machines
    - Compilers
    - HW design
    - System optimizations
- Numerous collaborators, projects, and open source results
    - >10 projects (EU, InnovateUK, Industry)
    - > 8M GBP
    - 6 Post-doc, 6 PhD, 2 MPhil, >20 UG, >10 PGT, Internships, etc.

Some data...

- Number of Repositories: > 52, > 2000 Stars
- Number of Contributors: > 25
- Actively Maintained LoC: > 800K
  - Java, C, C++, Python, Assembly – lots of assembly
- Number of downstream projects: 7
  - OpenJDK, GraalVM, JVMCI, Gem5
  - Apache Flink, OpenCL, OneAPI
- Resolved PRs: > 1000
- CI Infrastructure: GitHub actions, Travis CI, 35 in house regression servers
  - CPUs, GPUs, FPGAs
  - Various ISAs, vendors, configuration parameters

Beehive lab

Beehive lab is part of the Advanced Processor Technologies Group at the University of Manchester specializing in hw/sw codesign.

50 followers   United Kingdom   http://apt.cs.manchester.ac.uk/

Pinned   Customize pins

TornadoVM Public

TornadoVM: A practical and efficient heterogeneous programming framework for managed languages

● Java ☆ 1.2k ⑂ 117

Maxine-VM Public

Maxine VM: A meta-circular research VM

● Java ☆ 325 ⑂ 64

mambo Public

A low-overhead dynamic binary instrumentation and modification tool for ARM (both AArch32 and AArch64 support) and RISC-V (RV64GC).

● C ☆ 331 ⑂ 69

docker-tornadovm Public

Docker build scripts for TornadoVM on GPUs: https://github.com/beehive-lab/TornadoVM

● Shell ☆ 28 ⑂ 6

MaxSim Public

Forked from arodchen/MaxSim

A simulation platform for managed applications based on Maxine VM and ZSim
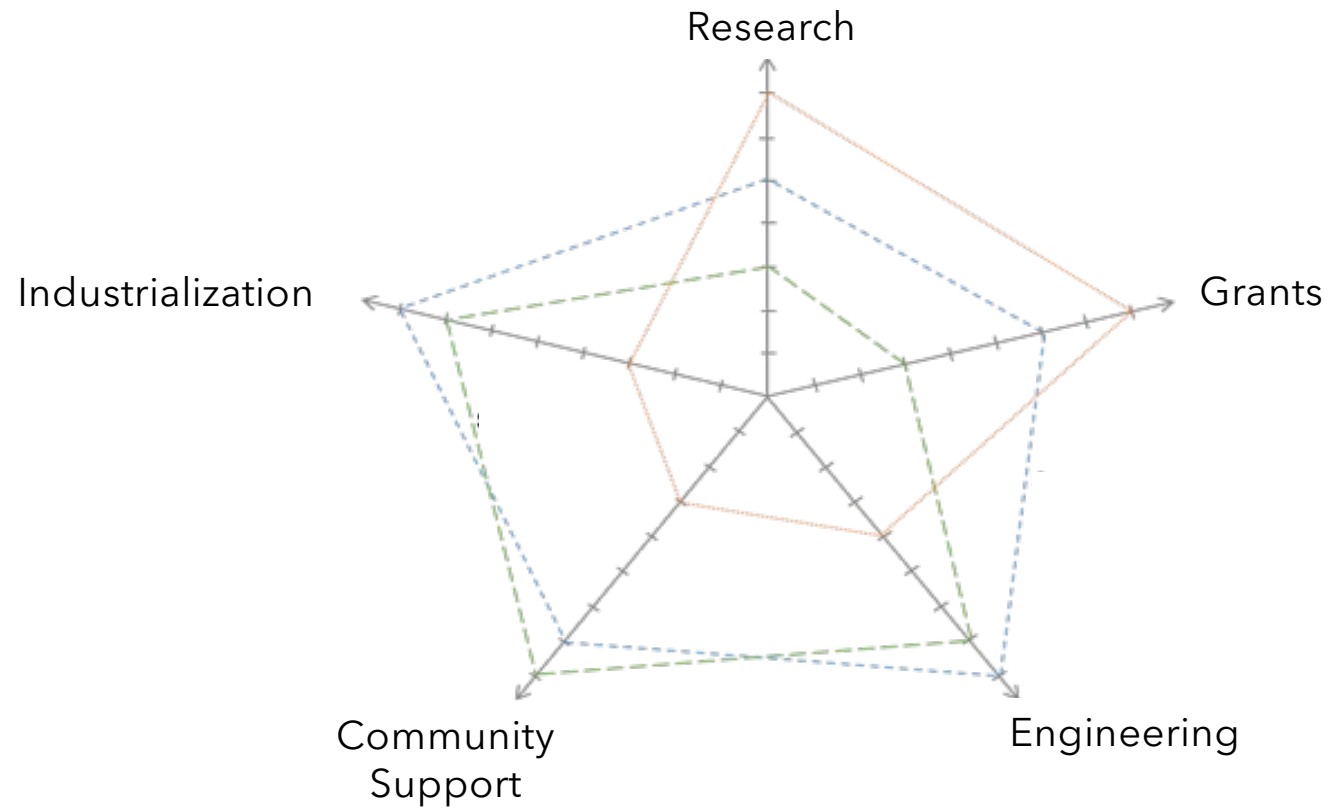
● Java ☆ 10 ⑂ 2

FastPath_MP Public

FastPath_MP: An FPGA-based multi-path architecture for direct access from FPGA to NVMe SSD

● C ☆ 32 ⑂ 4

Finding the pareto-optimal…
Open source is not easy

Lessons learnt and personal reflection

- Invest in state-of-the-art systems and try to keep up with them
- Grant alignment with research vision
  - Find partners who share same or similar vision
  - Avoid diversification that can hamper building expertise
- Complexity can become unmanageable
  - Students' onboarding, bug solving, corner cases, etc.
- Sometimes tough decisions need to be made:
  - Drop a subproject
  - Change system infrastructure
  - Focus on particular subsystems – opportunistic development
- Always plan *or have a plan* towards commercialization
- Build in-house expertise
  - Core development team with clear vision for growth and personal development

Thank you!

Questions?