From 5G to IoT, innovation starts with Qualcomm

$53+ billion cumulative investment in R&D

Source: Qualcomm data, as of Q3 FY18
Open Source Incentives

• Key historic incentives for participation:
  ◦ Hardware Vendors
  ◦ Sell Support and Services
  ◦ Provide Platform as a Service
  ◦ Auxiliary process and Infrastructure
  ◦ Talent Acquisition and Retention

• An example of shifting incentives in database technology.

• Future Shifts:
  ◦ Machine Learning
  ◦ Standards
  ◦ Open Hardware
Hardware Vendors

• Hardware vendors are incentivized to participate in Open Source to support the hardware they sell.
  ◦ Open source software support can be a key enabler to increasing chipset volumes and a differentiator with competitors.

• Examples:
  ◦ Linux Kernel
  ◦ LLVM
Support and Services

• Many companies have made a business out of supporting Open Source software and providing services.
  ◦ Participation gives them the expertise and reputation needed to perform the support and services.

• Examples:
  ◦ Distribution Support:
    • Red Hat
    • Canonical
  ◦ General Services:
    • Bootlin
    • Rogue Wave
    • Codethink
Platform as a Service

- PaaS vendors use Open Source to provide services.
- Incentives to participate include:
  - Improving engineering efficiency
  - Using developer familiarity to drive adoption
  - Enable features in the upstream
- Examples:
  - Elastic.co - Elastic Search
  - AWS - Apache Lucene
Auxiliary Process and Infrastructure

• Companies often participate for parts of their business considered auxiliary.
  ◦ Reduce operating costs by leveraging community and upstream model

• Examples:
  ◦ Google - LLVM
  ◦ Facebook - React
Talent Acquisition and Retention

• Talent acquisition and retention is (or should be an) incentive for all software related businesses.
  ◦ Developers want to be able to participate in Open Source
  ◦ Having an Open Source presence helps to find relevant developers.
Shifting Incentives

Example - Platform as a Service & Database Incentives

• Platform as a Service has made complex infrastructure simple.
• Example of a technology shift that modified incentives to participate in Open Source
• Unless you are an internet scale business or are a PaaS provider:
  ◦ Do you run or control the Operating System anymore?
  ◦ Do you run/control/modify middleware like databases, message buses?
Databases

Proprietary to Open Source Shift

• Proprietary Database
  ◦ Selected by the IT department!
  ◦ Pay a vendor for both the software and the service (support)
  ◦ Long turn around time for bug fixes or features specific to your use case

• Open Source Database
  ◦ Selected by developers
  ◦ May pay a vendor for service (support)
  ◦ Need to fix a bug? Add a feature? Self-service!
Databases

Cloud (PaaS) Shift

• End user abstracted from Database and Operating System implementation
• More economical to buy service than run yourself
• Pay a vendor for the service
• Need to fix a bug? Add a feature?
  ◦ Vendor request
  ◦ Upstream?
Example - Platform as a Service & Databases

Shifting Incentives

• Reduced incentive for **end user** to contribute to middleware like database
• **End user** incentive moved to cloud orchestration, cloud native deployment
• Platform as a Service value chain participates in Open Source database technologies
Shifting Incentives: Database/Middleware

**End User**

**Incentives**

**Historical**
- Use OS middleware to enable agile response to business demands and reduced operating cost.
- Participate to solve your own problems.

**Current**
- Use PaaS to provide middleware to reduce costs.
- Participate to enable efficient orchestration.
Future Shifts in Incentives

- Machine Learning
  - How do we shift incentives to broaden participation further?

- Standards
  - How to we enable participation for varied incentives?

- Open Hardware
  - How do we ensure the right incentives exist?
Machine Learning

• Boom of Open Source Machine Learning software being given away by those using it for their business.

• How do the related businesses make money? How do they differentiate if the software is available to all?
Machine Learning Incentives

• Companies using machine learning to monetize data.
  ◦ Incentives - increase efficiency, attract talent, leverage community support and expertise.

• PaaS companies also have an incentive to participate in machine learning Open Source as they can run machine learning as a service
  ◦ Incentives - increase efficiency, attract talent and use developer familiarity to drive adoption.

• Hardware vendors have incentive to participate in ensuring the software runs effectively on their hardware
  ◦ Incentives - sell more hardware.

• How do we continue the innovation in Open Source machine learning?
  ◦ Broaden the incentives to include companies where data is tangential to their business.
Open Data

• Enabling Open Data will continue the innovation boom in machine learning software.
  ◦ Extend the incentive to other businesses and business models.

• How do we open up data for sharing the same way we share software?

• Licenses for data.
  ◦ https://cdla.io
  ◦ https://creativecommons.org
  ◦ https://opendatacommons.org
  ◦ https://project-open-data.cio.gov/open-licenses/

• How much is this used in practice?
Example - Incentives when data is tangential to business

Example - Incentives when data is tangential to business

https://pixabay.com/illustrations/background-chalkboard-black-1206941/
Shifting Incentives: Machine Learning

**Current**
- Machine Learning software is an enabler. Value is typically in the data.
- Participate to share development cost, attract developer talent.

**Future**
- Open data plus machine learning can enable innovative new businesses and increase participation further.
Standards

• Historically limited incentives to directly participate in Open Source.
• Started participating to improve the speed of iteration and quality of standards.
• Standards are wide and varied in their complexity, so incentives may differ.
Standards - Collaboration Models

Commodity Technology — R&D Intensive
Standards - Collaboration Models

- Lower energy, higher accuracy
- Lower risk
- Invest in product development
- Roadmap (clarity)

- Higher energy, lower accuracy
- Higher risk
- Invest in R&D
- Science (might fail)
Standards - Collaboration Models

Inside SDO

SDO Standards

SDO Software

External Open Source Projects

Outside SDO

Contribution based on R&D

Public

Private

Standards Contributor

Commercial Product Sales

$
Shifting Incentives - Standards

• Open Source and Standards collaboration is not a one size fits all solution.
Future

- **Shared implementation** - Aligns with typical Open Source incentives and participation models.

- **Validate and improve standard** - Use Open Source and Open Source collaboration methods to drive the pace of standardization.
Open Hardware

• Existing commercial architectures:
  ◦ x86
  ◦ PowerPC
  ◦ SPARC

• Driven by vendor or a small set of vendors

• ARM architecture:
  ◦ Many SoC (System on Chip) vendors with different requirements
ARM and Linux Kernel circa 2010/2011

- Fragmentation between ARM SoC vendors and lack of upstream
- ARM Tree size
- ARM Tree changes between releases
- Linus
- Linux Foundation, Linaro and Vendor response.
Open Hardware

• What about an architecture without a main commercial backer?
• RISC-V - Open ISA (Instruction Set Architecture)
• Enables Open Source or Commercial Implementations
# Shifting Incentives: Open Hardware

| Vendor Incentive to Ensure Support. Software Support Need to Sell Hardware/Architecture. | Democratized, So Less Differentiation? Open and Collaborative? |
| Or “Leave it to the Others”? Tragedy of the Commons. |
Historical Incentives

• Hardware Vendors
• Sell Support and Services
• Provide Platform as a Service
• Auxiliary process and Infrastructure
• Talent Acquisition and Retention
Shifting Incentives - Future Examples

• Machine Learning:
  ◦ Will we successfully enable open data?
  ◦ Open data may be key to continuing innovation and broadening participation.

• Standards:
  ◦ Standard and Open Source collaboration may not be one-size fits all.
  ◦ We need a variety of models for standards to participate in open source

• Open Hardware:
  ◦ To avoid tragedy of the commons and unnecessary fragmentation we may need to align around open implementations.