



CMC Microsystems

Lowering barriers to technology adoption

SEPT 2020 | GORDON HARLING

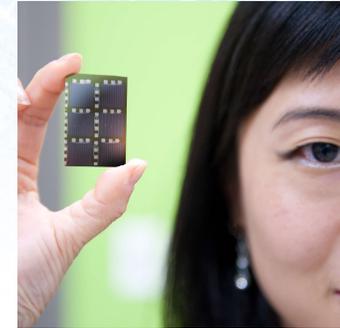
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CMC Microsystems

CMC provides services for research and training required to advance Canada's digital economy:

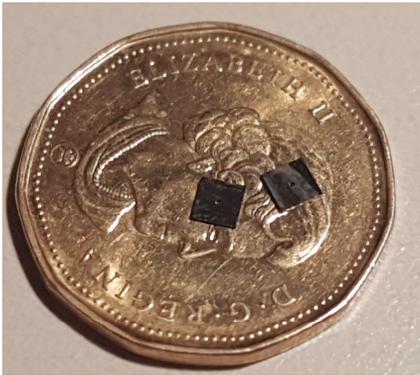
- Industrial automation
- autonomous vehicles,
- Internet of Things (IoT),
- cyber defence and security,
- quantum computing,
- artificial intelligence (AI) and big data



Academic and Industrial Users

- > Not-for-profit founded in 1984
- > Manages Canada's National Design Network® CNDN
- > Delivers products and services across Canada (and internationally)

What are micro-nanotechnologies?



Atomic Force Microscope developed at University of Waterloo and by ICSP Inc.

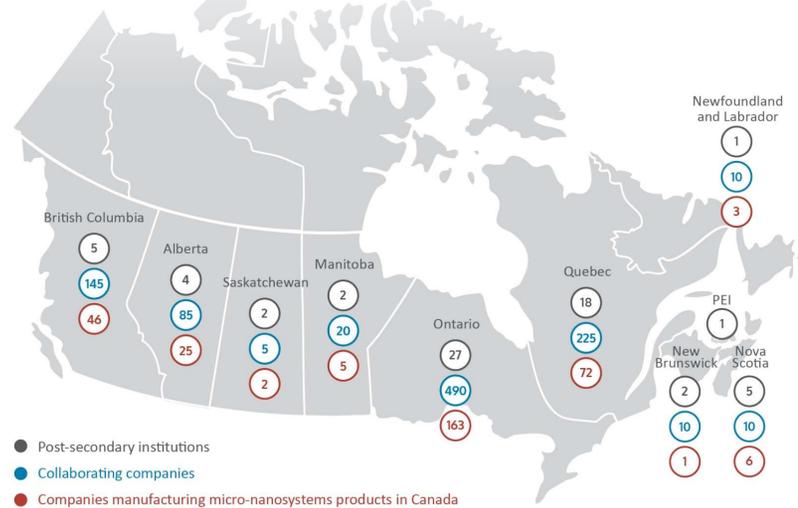
- > Highly miniaturized electronic or mechanical devices, such as processors, lasers, and sensors
- > Manufactured to tolerances of billionths of a metre
- > Includes:
 - Microelectronics
 - MicroElectroMechanical Systems (MEMS)
 - Photonics, Optics, and Quantum
 - Embedded Computing (AI, ML)

Canada's National Design Network[®]

A Canada-wide collaboration between 67 universities/colleges to connect 10,000 academic participants with 1,000 companies to design, make and test micro-nanosystem prototypes.

2018 Outcomes

- 3 655 publications
- 165 awards
- 85 patents awarded
- 555 collaborations with industry
- 20 new startups
- 785 trained HQP moved to industry



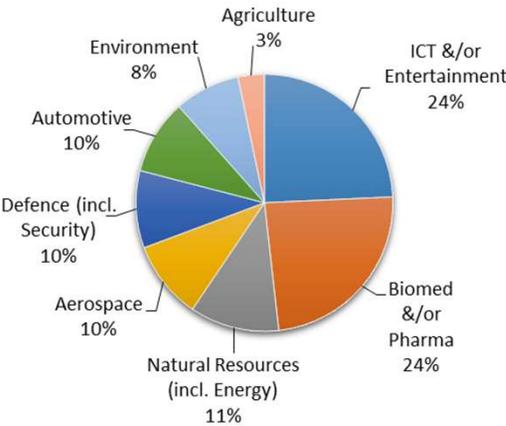
Annually

- 1 250 connected professors
- 8 850 researchers on professors' teams
- 6 200 users of computer aided design tools
- 360 physical prototypes
- 80 equipment rental items otherwise unaffordable

CMC manages Canada's National Design Network[®]

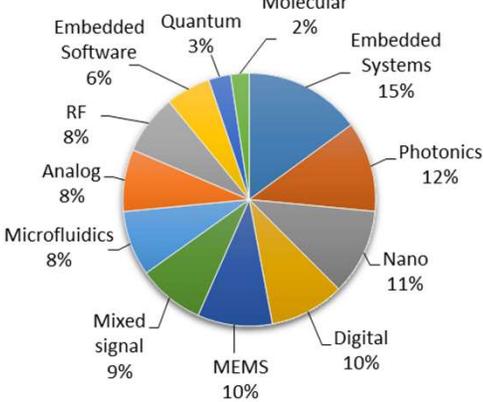
CNDN Academic Landscape 2018

Technology Application



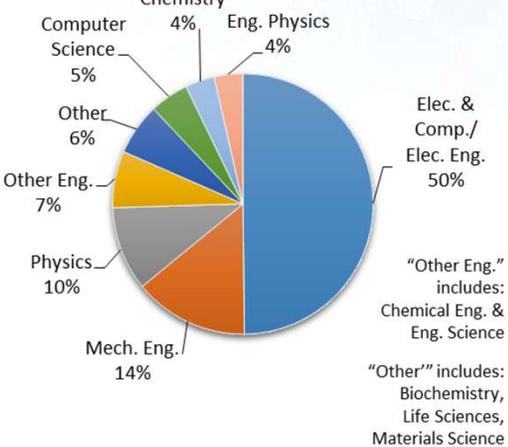
of professors = 1117
of interests = 3138

Design-Oriented Interests



of professors = 1164
of interests = 4621

Disciplines/Departments



of professors = 1264

Global partners

Worldwide industrial supply chain
– supporting research excellence



North America

Canada

14 CAD | 8 Fab | 13 Test
19 Systems & Components
42 University MNT Labs

USA

1 Co-operative Initiative
15 CAD | 5 Fab | 11 Test
8 Systems & Components

Europe | 1 European Co-operative Initiative

Ireland

1 Fab

UK

1 CAD
1 Systems &
Components

France

2 Fab
1 Co-operative
Initiative

Sweden

1 CAD

Netherlands

2 Fab

Belgium

1 Fab

Germany

1 CAD
2 Fab

Austria

1 Fab

Asia

China

1 Co-operative Initiative

South Korea

1 Co-operative Initiative

Japan

1 Co-operative Initiative

Taiwan

1 Co-operative
Initiative
2 Fab
3 Systems &
Components

Singapore

3 Fab

Startups: 2018

Impact	2014	2015	2016	2017	2018	5-year:
Startup companies*	13	21	16	15	20	85

Startup Companies Reported in 2018

Company	University	Company	University
AgileMMIC	University of Calgary	MYCIONICS	Western University
All Waves Technologies	Université de Sherbrooke	nPLex Biosciences	McGill University
CleanTech Geomechanics	University of Waterloo	SenZioT Technology	University of Alberta
DropGenie	Concordia University	SHIELD Crypto Systems	University of Toronto
DropTissue BioTech Inc	University of Calgary	Smart EDA Technologies	University of Guelph
Durabrace	University of British Columbia	SmartRF Inc.	University of Calgary
Get Smart Analytics	University of Ottawa	Tibor Designs	University of Ottawa
Harvest Systems Inc	McMaster University	VisuCyte Therapeutics Inc. (VCT Inc.)	University of British Columbia
Mazlite	University of Toronto	VueReal Technologies	University of Waterloo
Micromensio	University of Toronto	Ziprprint	University of Alberta

*Startup companies based on actual data only.

Lowering barriers to technology adoption

CAD



State-of-the-art environments for successful design

- ✓ Selection of high-performance Computer Aided Design (CAD) tools and design environments
- ✓ Available via desktop or through CMC Cloud
- ✓ User guides, application notes, training materials and courses

 [CMC.ca/CAD](https://cmc.ca/CAD)

FAB



Services for making working prototypes

- ✓ Multi-project wafer services with affordable access to foundries worldwide
- ✓ Fabrication and travel assistance to prototype at a university-based lab
- ✓ Value-added packaging and assembly services
- ✓ In-house expertise for first-time-right prototypes

 [CMC.ca/FAB](https://cmc.ca/FAB)

LAB



Device validation to system demonstration

- ✓ Access to platform-based microsystems design and prototyping environments
- ✓ Access to test equipment on loan
- ✓ Access to contract engineering services

 [CMC.ca/LAB](https://cmc.ca/LAB)

CMC provides leverage to researchers!

CAD

Purchases licences in bulk from over 30 suppliers and shares them across Canada over the internet

FAB

Makes minimum purchases from commercial factories (often 50k\$ to 200k\$) and shares the space among many researchers – Multi Project Wafers or MPW

LAB

Finds suppliers for unique requirements among the 40 nano-fabrication facilities across Canada
Develops platform technologies of use to many researchers



CAD – Access and Support



... AND MORE

Over **500 CAD** tools
and modules

PDK, training, support

Over **5000**
individual users
annually



FAB – Industrial Foundry Runs

A global supply chain enabling access to advanced microelectronics, photonics, MEMS, microfluidics, and embedded systems technology



DESIGN KITS

MICROELECTRONICS

- [Analog/Mixed Signal Design](#)
- [STM 28nm CMOS FD SOI](#)
- [STM 28nm CMOS LP](#)
- [TSMC 65nm CMOS GP](#)
- [TSMC 65nm CMOS LP](#)
- [TSMC 90nm CMOS](#)
- [IBM 0.13µm CMOS](#)
- [TSMC 0.18µm CMOS](#)
- [AMS 0.35µm CMOS](#)
- [TSMC 0.35µm CMOS](#)
- [Teledyne DALSA 0.8µm CMOS](#)
- [2.5GHz Bipolar Linear Array](#)
- [NRC GaN150](#)

EMERGING TECHNOLOGIES

- [Interposer Platform PDK for 2.5D Integration](#)
- [Open-Gate Silicon JFET](#)
- [Univ. of Waterloo UW-MEMS](#)

PHOTONICS

- [CMC/CPFC III-V](#)
- [AMF Si Photonics](#)
- [Silicon Photonics Design Platform](#)

MEMS

- [Teledyne DALSA MIDIS](#)
- [Micralyne MicroGEM-Si](#)
- [MEMSCAP PiezoMUMPs](#)
- [MEMCAP PolyMUMPs](#)

MICROFLUIDICS

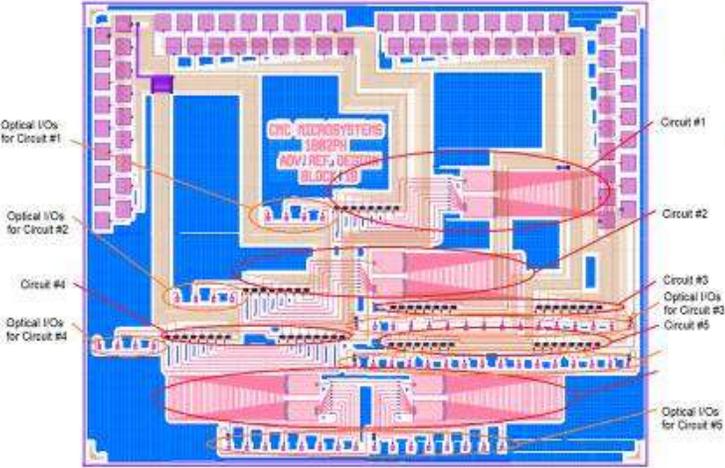
- [Micronit Sensorit](#)
- [FlowJEM](#)

A typical LAB project...

Advanced Reference Design (7/7)



- Chip Layout for fabrication (AMF 1802PH MPW run)



- AWG DEMUX and micro-ring array MUX
- Different circuits are for different separation between bus and micro-ring (200nm, 300nm, 400nm, 500nm)



CMC Commercial Services

CMC negotiates with suppliers to provide tools to SMEs:

- Design tools in the cloud, no installation required, high performance acceleration
- Access to cost-shared fabrication services
- Technical assistance from CMC staff



CMC Microsystems provides tools and services for the creation of hardware in microelectronics, photonics, and electro-micro-mechanical systems (MEMS).

Computer Aided Design (CAD) tools

- Access to ANSYS, ~~UG~~ ~~CAD~~ ~~CAE~~ SolidWorks, Tanner and other tools*
- Delivery via CMC Cloud, a protected environment that transforms your laptop into a secure, high-performance design lab
- Fully configured, installed, and hosted by CMC with continuous software updates to reduce costs and accelerate your start-up
- Access training courses, webinars, and documentation through CMC

Commercial Fabrication Access

- Access to state-of-the-art processing in
 - Microelectronics down to 12 nm
 - Silicon Photonics
 - Micro-~~Electro-Mechanical~~ Systems (MEMS)
- Cost sharing using Multi-Project Wafers for prototyping/low volume
- Assistance in Packaging and Testing your device

R&D Services

- Hardware and software for Artificial Intelligence and Machine Learning
- Royalty free IP
- Access to custom nanofabrication labs
- Support for building research networks with academic institutions
- Access to our equipment loan pool for short term needs
 - * Some services require additional fees.

Annual fee
\$2 000 CAD
per company

Hosting of commercial licenses of Computer Aided Design tools

Cost Sharing on commercial fabrication services

Assistance in Test and Packaging

CAD Cloud



www.cmc.ca/tools

FAB Partners



www.cmc.ca/technologies



CMC Research Services

For large companies CMC increases Canadian content and promotes academic and industrial interactions:

- Create research networks from our 67 member universities and colleges
- Promote Canadian suppliers
- Technical assistance from CMC staff



CMC Microsystems is pleased to offer the SponsorChip program for companies to enhance their research efforts and their links to academic researchers. Under this program companies may choose a process technology and an area of Interest and CMC takes care of the rest.

What you Get

- ✓ Faculty: low cost silicon that allows you, your students, and your research staff to test out new ideas and to publish
- ✓ Sponsor: Stimulate the research community in your area of interest, identify potential future partners, explore the design and manufacturing space, submit your own designs and benefit from CMC support
- ✓ Intellectual Property: it is the sponsor's responsibility to negotiate for rights should they wish to do so.

Sponsorship Examples:

TSMC 65 nm Standard Process:
CAD\$80 000

Average 12 mm square area

Average 6 to 12 design submissions

Technical and Logistical support from CMC



For example, the sponsor selects:

- 130 nm from TSMC, research area: low power electronics for IoT
- 65 nm from TSMC, research area: CMOS RF circuits
- Silicon Photonics with Active components from AMF
- MIDIS Inertial Sensor process from Teledyne

CMC provides

- a call for proposals from over 4 000 researchers in its network,
- full suite of CAD software to researchers undertaking the sponsored activity
- hands-on training and support of researchers and students from schematic to layout to package and test
- a timeline for design submission, fabrication, and test
- reviews of the sponsored activity to ensure quality and return on investment
- testing support through equipment loans and process debug

More details at www.cmc.ca/fab



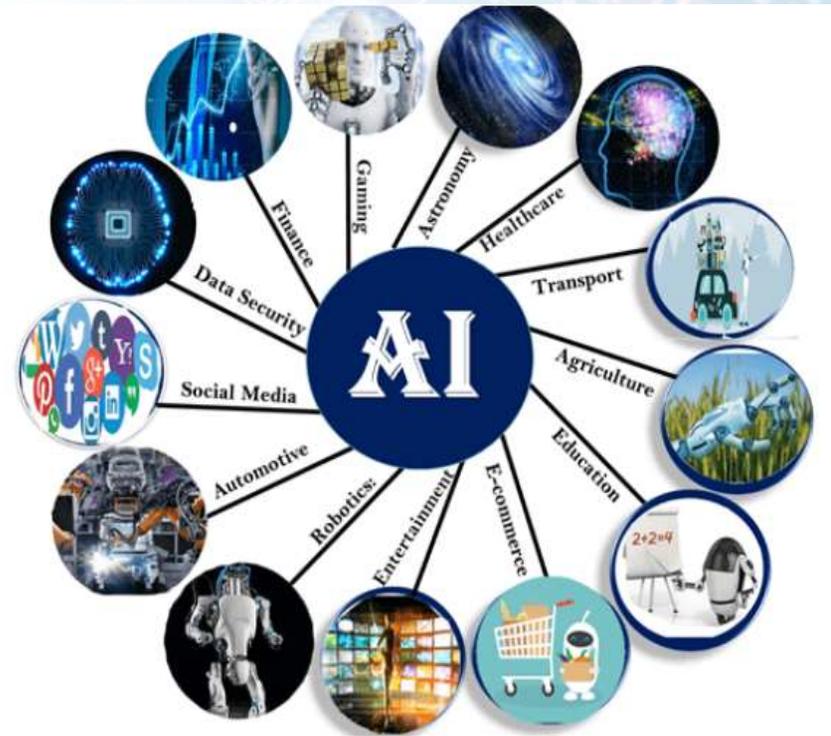
Artificial Intelligence (AI) and Machine Learning (ML)

..and how CMC can help



Applications of AI

- **Computers optimize their own performance using sample data or past experience**
 - Artificial Intelligence (AI) : Sense, reason, act, and adapt
 - Machine Learning (ML) : Algorithms improve as they are exposed to data over time
- **Transforming many industries**
- **Exploding ecosystem of tools and platforms**



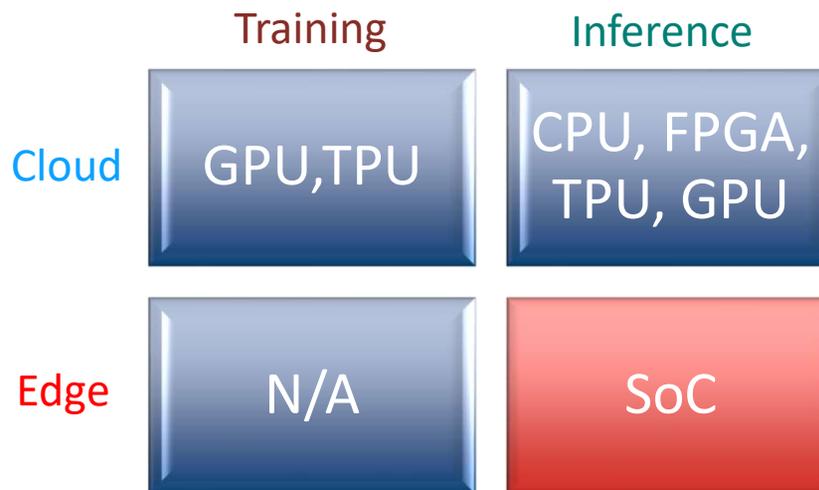
Two Things to know about AI

Learning

- Done on large data sets in large compute centers (the cloud)
- Hardware has evolved from arrays of CPU to GPU to TPU

Inference

- Information from the learning phase is used to make a decision or manipulate data
- This is often done at the edge of the internet in sensors like cameras or microphones



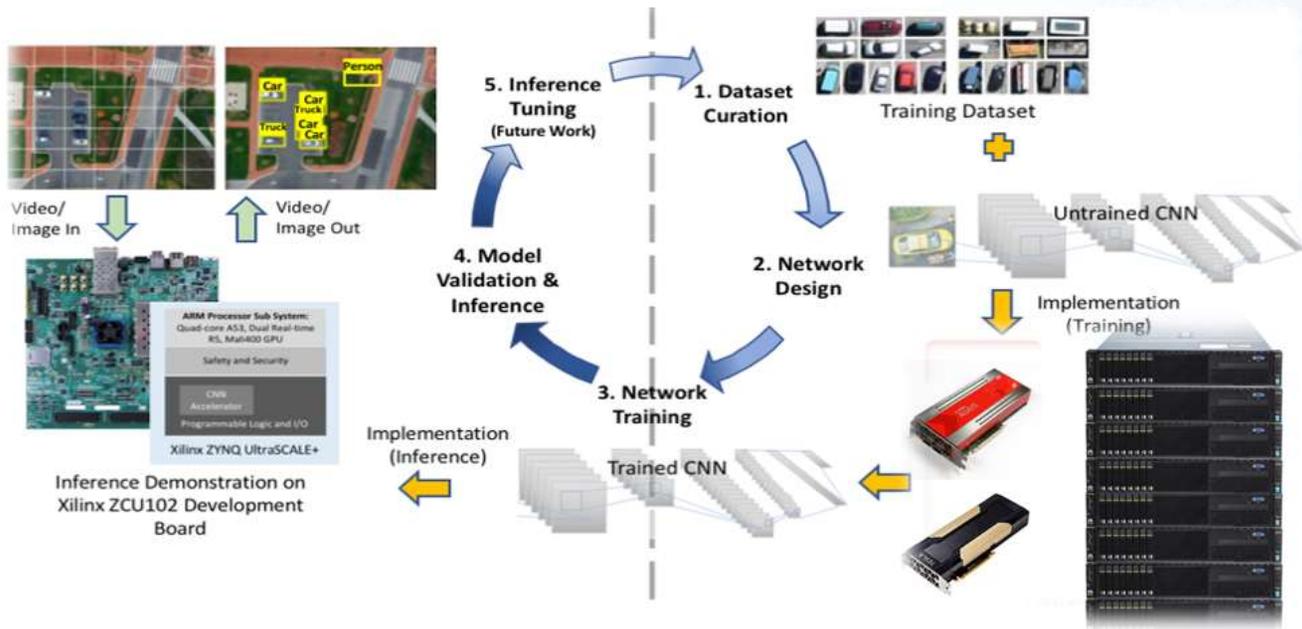
CPU – Central Processing Unit
GPU – Graphical Processing Unit
TPU – Tensor Processing Unit
FPGA – Field Programmable Gate Array
SoC – System on a Chip



Cloud-edge AI platform for CNN training and inference

2 – Deploy (Inference)

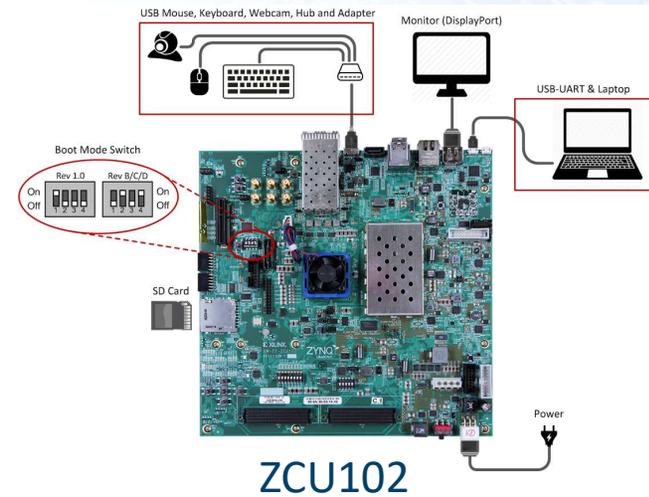
1 – Build (Training)



Inference on an edge device: ZCU102



Demo – Object detection and tracking in real time



How does CMC help?

Support for Development

- AI/ML Accelerator housed in Graham Compute Center in Waterloo
- GitHub repository for royalty free software and hardware
- Path to silicon – design flow

Heterogeneous Compute Cluster

– 8 nodes delivering 43 TFLOPS

Node configuration:

- Dual 12 core 2.1-3.0 GHz CPU
- 192GB RAM
- 600GB local storage
- 100Gb EDR node interconnect
- 10GbE storage network
- **Xilinx SDAccel Virtex UltraScale+ FPGA**
- **NVIDIA V100 GPU**



How does CMC help?

Support for Custom Processors (RISC-V)

- Founding Member of OpenHW
- Multiple projects for development of custom hardware devices for
 - DNA analysis,
 - medical imaging,
 - radiation hardened computers
- Project results are offered free of charge to research and industrial communities



RISC-V Processor Design and Prototyping

RISC-V is a free, open instruction set architecture, (ISA) that enables processor innovation through open standard collaboration. The RISC-V ISA provides the research community with an opportunity for innovation in new system products, particularly for machine learning and edge computing.

CMC helps realize RISC-V designs by offering:

- Silicon-proven design platforms based on OpenHW Group CORE-V family of open-source cores
- CAD tools and flows for virtual system prototyping and ASIP design, physical implementation, PCB design, and software development
 - Industry-standard tools from Cadence Design Systems, Synopsys, and Mentor Graphics
 - CMC Cloud access, pre-configured to ensure quick and easy desktop use
- FPGA platforms for system emulation and validation, early software bring-up and debug
 - Available on-site, through short-term rental or via CMC cloud access
- Design kits for fabrication in commercial technologies from 350nm down to 22nm
 - Including digital cells, memory, and I/O blocks
- Multi-project wafer services for fabrication
- Packaging and assembly services
- Access to test equipment

About CMC

Lowering barriers to technology adoption

CMC helps researchers and industry design and develop innovations in microsystems and nanotechnologies.

About OpenHW Group

OpenHW Group is a not-for-profit, global organization driven by its members and individual contributors where hardware and software designers collaborate in the development of open-source cores, related IP, tools and software. OpenHW provides an infrastructure for hosting high quality open-source HW developments in line with industry best practices.
<https://www.openhwgroup.org>



Quantum Computing

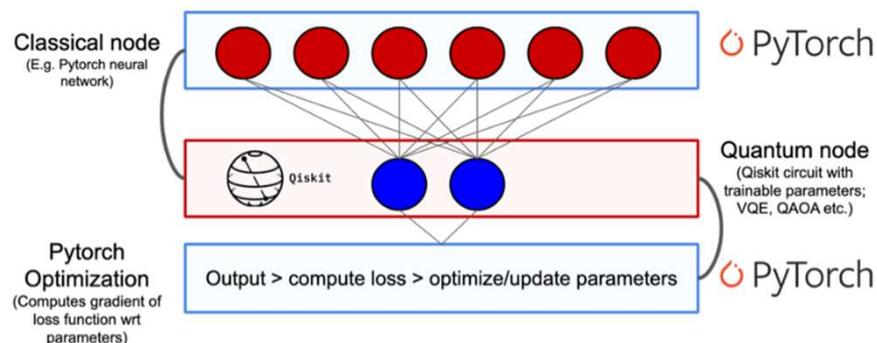
..and how CMC can help



How does CMC help?

Quantum as a Service (QaaS)

- Member of the IBM Q HUB in Canada
- CMC's quantum coder team at the Institut Quantique in Sherbrooke
- CMC takes computational problems from clients and helps them interpret the results
- CMC works on projects such as hybrid computing with research partners



Team QizGloria at the 2019 Qiskit Camp Europe integrated Qiskit with PyTorch, an open-source machine learning framework.



How does CMC help?

Quantum Hardware

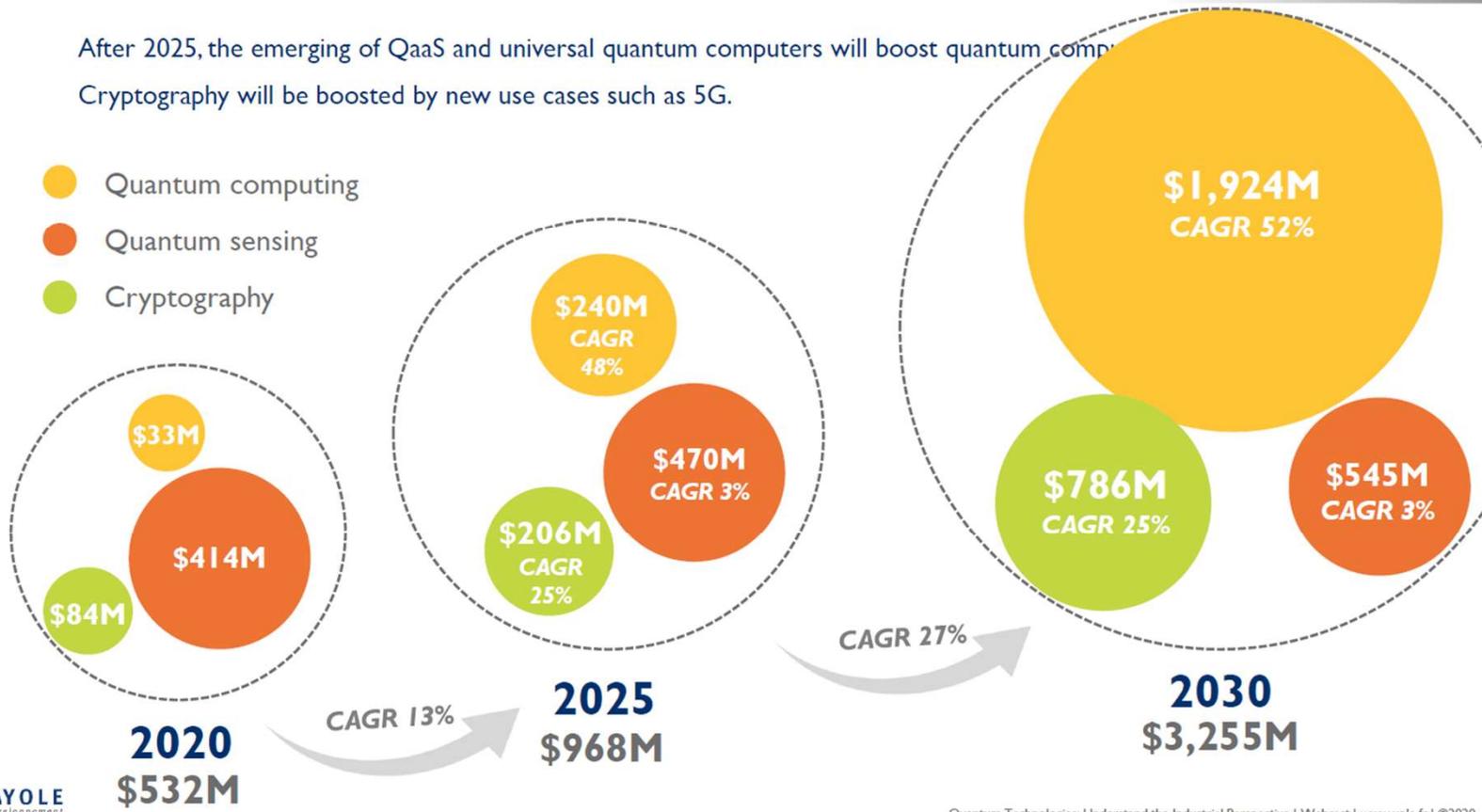
- CMC partners with CNDN researchers to develop
 - cryogenic circuits to write/read qubits (Univ de Sherbrooke)
 - packaging technology for cryogenic circuits (Tyndall, U of T, U de Sherbrooke)
- CMC is supporting training, and deploying simulation tools for materials research (UBC, U Vic, SFU)



2020 – 2025 – 2030 QUANTUM TECHNOLOGIES FORECAST

After 2025, the emerging of QaaS and universal quantum computers will boost quantum computing.
 Cryptography will be boosted by new use cases such as 5G.

- Quantum computing
- Quantum sensing
- Cryptography



What is CMC's role in Quantum Technology?

Hardware Development

- Design and fabrication support for quantum sensors, quantum communication devices, and computation (qubits)
- Training support (CREATE SiEPIC QC program with UBC, SFU, U Vic)
- Hardware development to simplify fabrication (IBM, INO, NRC, ANT, many universities across Canada)

Quantum as a Service

- CNDN has 190 quantum researchers in its network, CMC can provide services across Canada to promote interaction and accelerate innovation
- CNDN can offer quantum computing services to every region of Canada



Where are we now?

Canada is established in AI/ML and Quantum

- Investments per capita were well ahead until recently (China and US)
- Researchers are well reputed and referenced internationally

To win world-class status in these areas will require a broad research consortium with strong interdisciplinary collaboration...



Where do we go from here?

The Opportunity

- Quantum computing is comparable to traditional computing of the 1970s, many breakthroughs are going to occur in both hardware and software
- Quantum computing and AI are going to co-exist in a hybrid model, we need the skills to make them synergistic
- There are many areas to be studied from the materials science of building better qubits to creating the software to run machines combining AI and QC

Can Canada create and drive a vision to take a global lead?



Thank you!

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