IEEE Quantum Computing Summit

Erik P. DeBenedictis¹, ²

¹IEEE Rebooting Computing Initiative
²Center for Computing Research, Sandia
Introductions

• Bill Tonti, IEEE Future Directions Committee
  – Bill proposed the activity and is responsible for funding
• Travis Humble, Oak Ridge
• Scott Holmes, Booz-Allen Hamilton
  – Technical Organizers
• Terence Martinez, IEEE Future Directions Committee
  – Meeting arrangements
• Lee Gomes
  – Writer

• Everybody else
  – Let’s go around the room and have everybody state their name and affiliation
Outline

- Context, goals, objectives, and resources
- Quantum Computer Scale up
- Schedule of the Meeting
Summit Overview

Context
• Quantum Computing is getting increased attention
• IEEE seems expected to play role in quantum computing
  – But IEEE is a blank slate right now; no commitments to anybody
• Objectives
  – Propose a position for IEEE on what’s realistic
  – Propose future activities for IEEE
  – Propose a follow-on to this summit; we have a budget
Format of Summit

Guided working group
• Not a meeting for participants to present their work
• Five plenary presentations to provide context
Three 2-hour periods of three tracks, total 9 sessions
• Each group discusses one issue per session
• Create a couple PowerPoint slides and out brief
• Create some notes for Lee Gomes
• We’ll jointly organize sessions so common interests are sequential in time (hardware/software/etc.)

Participants don’t have to follow the issues as defined
Google Doc

The agenda is an editable Google Doc
- Google Docs is a double-edged sword
- https://docs.google.com/document/d/1gwQIhNbkMGiZEyHSmfimcYQsrWdY2c_Ly3uMP3b0yGQ/edit

Erik DeBenedictis has a directory with some files
- http://www.debenedictis.org/erik/qc-summit/
- If you forget the Google Docs link, it is in agenda.pdf in the directory

We’re not going to use the Google Doc for much longer
Additional Logistics

A day-and-a-half

• All day Thursday; until 2 PM Friday
• I’m not leaving until later; could continue

Lunch and break provided

• Dinner on your own (but we may organize on the fly)

Lee Gomes will create the whitepaper

• The group will review the whitepaper and fix it or supply additional content as needed
Erik’s View on Type of Things
IEEE Can Do; Debate if you Disagree

IEEE ought to be an honest broker, neutral on issues where members compete
• IEEE should have no opinion on which qubit is better
IEEE can have opinions on some issues
• Examples: Ethical conduct awareness, blockchain
IEEE can offer its traditional services
• Conferences and publications on quantum engineering
IEEE Standards Organization
• IEEE Standards are ways companies can communicate with some legal implications
• Terminology, metrics, etc.
Quantum Computing or QIS, etc.? 

Academic communities embrace the following hierarchy

- Quantum information sciences, comprised of
  - Quantum computing
  - Quantum communications
  - Quantum Sensors

- Post Quantum Cryptology

As far as I can tell…

- IEEE will cover it all at some point
- Quantum computing is in-your-face and urgent
- This group can issue a finding to rescope (question 10)
Outline

- Context, goals, objectives, and resources
- Quantum Computer Scale up
- Schedule of the Meeting
Top level issue (my view)
• The hype around Moore’s law is amplifying hype about quantum computers
• I believe “hype control” will be the top-level contribution for IEEE

Technical origin and solution
• Moore’s law doesn’t apply to all integrated circuits, just ones that have been carefully designed to scale
• Qubits won’t scale until one is carefully designed so it does
• Problem is that society jumps over the hard work
A little more detail
• Moore’s wrote his famous paper after industry redesigned one form of integrated circuit so it scaled
• Forget “is Moore’s law ending?”; the first integrated circuit was bipolar and stopped scaling long ago
• Other people figured out how to make MOS, FinFET, etc. scale, but not GaAs

Quantum computers
• We’ve been making scalable device families for years; so why not a scalable qubit?
Quantum Computer Scale Up I

**Classical**

“Flying wire” integrated circuit

[Fragile structure in the third dimension, scaling probably not possible](http://www.computerhistory.org/revolution/digital-logic/12/276/1417)

**Quantum**

Quantum “chandelier”

[Note: This is at the bottom of a “chandelier”](https://spectrum.ieee.org/tech-talk/computing/hardware/tiny-quantum-computer-simulates-big-molecules)

---

**Solid-state structure, except bonding pads, probably possible**

555 Timer (1971)

https://en.wikipedia.org/wiki/555_timer_IC

IBM 7 qubit chip

Quantum Computer Scale Up II

First Example of Scaling

- The integrated circuit Nobel prize was for TI “flying wire” integrated circuit, which wouldn’t scale physically due to wiring in the third dimension.
- The “planar” integrated circuit eventually scaled, but only after electrical design advances like isolation wells and insulating layers.
- Materials defects limit scaling of bipolar and MOS, but it was not known at the beginning that materials defects would be worse in bipolar.
A Year Before Moore’s Paper

- 10 articles in IEEE Spectrum special issue June 1964 →
- Moore’s paper 1965
- The industry was reinvesting profits from improving avionics from discrete transistors to precursors to integrated circuits
- Is this the next few years of quantum computing?
Pre Gordon Moore

Before Moore’s contribution

• Industry worked hard on improving integrated circuits so they scaled
• However, they didn’t know they’d achieved a milestone because scalability had not been invented as a goal
• Note horizontal axis is number of pins
Gordon Moore’s Contribution I

- Assessed cost per component given reliability, material (silicon), yield, complexity, die size, interconnection space, heat, speed, power per unit area, design automation, linear, RF

- Data over multiple generations and extrapolated

Gordon Moore’s Contribution II

Functional complexity evolves from

• Pins
• Components
• Next is quantum speedup
Outline

• Context, goals, objectives, and resources
• Quantum Computer Scale up
• Schedule of the Meeting
Schedule – Actual

• Thursday 8:30 AM Intro talk – Erik DeBenedictis
• 9:15 AM Technical vision talk – Norbert Linke, hardware/physics
• 10:15 AM Technical vision talk – Andrew Sornborger, applications
  – http://www.debenedictis.org/erik/qc-summit/IEEEQuantCompSummitATS.pdf
• 11:00 AM Discussed deleting the proposed schedule and having an ongoing discussion group – passed by show of hands
• Noon: lunch
• 1:00 PM Continue discussion group (until 5:00 PM)
• 6:30 PM Two groups went to dinner
• Friday 8:30 AM Benchmarking discussion
• Noon: lunch
• 1:00 PM Continue discussion group (broke up 3:30 PM +/-)