IEEE Quantum Computing Summit

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This summit meeting's agenda is a Google Doc located at
https://docs.google.com/document/d/1gwQIhNbkMGiZEyHSmfimcYQsrWdY2c_Ly3uMP3b0yGQ/edit
The intention is that participants may edit this document on an ongoing basis. However, some people behind firewalls may have trouble accessing Google Docs. Therefore, a copy of the document is provided in a private directiory http://www.debenedictis.org/erik/qc-summit/agenda.pdf The pdf version may not be entirely up to date with any edits on this site.

Summit Logistics

The summit will be at the

Georgia Tech Global Learning Center
84 5th St. NW,
Atlanta GA.

Please plan on being at the learning center from 8:30 AM -- 5:00 PM on August 30 and 8:30 AM -- 2:00 PM on August 31; however, discussions may extend beyond these times.

Georgia Tech has arranged a special rate of $154 per night at the Ga Tech hotel (GEORGIA TECH HOTEL AND CONFERENCE CENTER 800 Spring St. NW, Atlanta, GA 30308). Sorry about the disorganization with regards to the hotel, but the hotel has now provided the information in the dozen lines below this paragraph, which includes a link for online reservations. The government rate is $148 (no longer available).

Hotel

Click on the link to book your reservations for IEEE Quantum Summit Rolling Room Block on August 29th, 2018 through August 31st, 2018

IEEE Quantum Summit Rolling Room Block-Reservations Link

Non-smoking King and Double bedding accommodations have been blocked for this group. **Please note that all guestrooms are non-smoking.** *For any other requests or inquiries, please enter this information within the appropriate request boxes during the reservations process or call the hotel directly by calling (800) 706-2899 or (404) 838-2100, Monday-Friday from 9am-6:30pm.*

Booking Deadline: 08/22/2018

For any additional nights needed before or after the posted group dates, please contact the hotel directly at (800)706-2899 to check availability.

For those attendees driving to the hotel, overnight parking is $15 per night.
(For unlimited in and out access to the garage, an $18 pass is available.)

Resources

Agenda

The IEEE Quantum Computing Summit's agenda is a Google Doc located at the following URL:
https://docs.google.com/document/d/1gwQIhNbkMGiZEyHSmfimcYQsrWdY2c_Ly3uMP3b0yGQ/edit
Alternate location of a pdf "snapshot": http://www.debenedictis.org/erik/qc-summit/agenda.pdf

Call for Papers

Erik DeBenedictis and Travis Humble have convinced IEEE Computer magazine to publish a special issue on the topics of this conference. See
https://publications.computer.org/computer-magazine/2018/08/09/quantum-realism-realistic-future-quantum-computing-call-papers/

Meeting with OSTP and NIST

Several of us associated with the summit had a meeting with OSTP and NIST on August 17. The meeting provided key insights into the ways IEEE can cooperate with the US Government. In fact, these insights may apply to any neutral, non-profit, organization and any government. The complete meeting notes had two section (2 and 6) that seem inappropriate for posting here because these documents may become accessible to the public
http://www.debenedictis.org/erik/qc-summit/ostp%20mtg%20summit%201.pdf

Objective of Summit

Recent technical advances are driving rapid growth of interest and attention to quantum computing. While IEEE already has a modest number of activities that include quantum computing, the goal of this summit is to start developing a position that may apply more broadly.

IEEE is in an unusual or unique position amongst players in quantum computing. IEEE is not competing with any other organization and can work with the government in some cases. IEEE does not perform or fund research directly and will not be a prime user of quantum computers. However, IEEE could be very influential through its conferences, publications, roadmap, its members in general, and its outreach in areas like education and public policy. IEEE's unique position suggests a unique positioning for IEEE. This summit will propose a candidate position.

This meeting is organized like other workshops or summits, which often take a path different than the organizers anticipated. The organizers' plan is to produce a white paper with a candidate quantum computing position for IEEE. The summit will have plenary talks and three sessions of parallel working

groups. Each group will address issues that could become sections of a whitepaper and present a summary near the end of the summit. A writer will be present at the conference and will draft a white paper afterwards, circulating it to participants and a few other interested parties.

Thursday August 30

8:30 AM Intro talk – organizational (speaker TBD)

9:15 AM Technical vision talk – hardware/physics (speaker TBD)

10:00 AM Technical vision talk – Andrew Sornborger, applications and algorithms area

10:45 AM Working group organizational instructions

Spend 15 minutes in plenary session discussing division into three groups. Each group will draft a position statement or other explanation on an issue in quantum computing, leading to a PowerPoint summary presentation and notes for the white paper. The solutions need to be expressed in a way that is understandable to non-experts, which should be straightforward because the groups themselves contain both experts and non-experts. Three issues appear below for the first group session; the issues appear as just titles, but there is more detail in the appendix at the end of this document. Groups may use the issues suggested by the organizers or may choose their own. These and following sessions are labeled as Apps, Hardware, or Programmatic to guide participant interest.

1. (Apps) Quantum computers find better solutions to current problems. POC: Andrew Sornborger. Interest group: Catherine McGeoch___.

2. (Hardware) Preparation for hardware scale up. POC: Scott Holmes, Paolo Gargini. Interest group NM Linke___.

3. (Programmatic) What Rebooting Computing should do next (RC Week)? POC: Bruce Kraemer. Interest group: ___.

11:00 AM Divide into working groups (first hour). Three breakout rooms will be available: 318, 319, and 323. If a fourth group forms, it could meet in the general session room.

Noon: lunch

1:00 PM Continue working groups (second hour). Complete vision statement and prepare a summary presentation.

2:00 PM Vision statement summary presentations, 20 minutes per group.

3:00 PM Talk – How to use research prototypes to create engineered, replicable quantum systems, or changing prototype designs to make this possible, based on experience with semiconductors. Paolo Gargini.

4:00 PM Divide into working groups, not necessarily the same groups as in the morning, with each group addressing a new issue, such as those listed below. As before, the groups may change the issue.

4. (Apps) New applications. POC: TBD. Interest group: ___.

5. (Hardware) Quantum benchmarks. POC: Travis Humble. Interest group: Catherine McGeoch NM Linke.

6. (Programmatic) New quantum conferences and publications. POC: Elie Track. Interest group: ___.

7. (Extra group) Quantum computer software engineering. POC: Tom Conte. Interest group: ___.

6 PM dinner

Friday August 31

8:30 AM Summary presentations, 20 minutes per group.

9:30 AM Talk TBA

10:15 AM Divide into working groups, not necessarily the same groups as in the morning, with each group each addressing a new issue, such as those listed below. As before, the groups may change the issue.

8. (Apps) Quantum machine learning. POC: Andrew Sornborger. Interest group: NM Linke___.

9. (Hardware) Quantum roadmap. POC: Scott Holmes, Paolo Gargini. Interest group: ___.

10. (Programmatic) Support for other parts of QIS and new technical areas. POC: Steve Bush. Interest group: ___.

11. (Extra group) IEEE's role in quantum computing education. POC: Steve Bush. Interest group: ___.

Noon: lunch

1 PM: Summary presentations, 20 minutes per group.

2 PM additional discussion format TBD

5 PM summit ends

Post Summit Activities

The writer will create a position paper for IEEE and share it with attendees for feedback. The organizers suggest a follow-up meeting at the International Conference on Rebooting Computing (ICRC 2018), November 7-9 in Washington, DC, USA.

Appendix: Organizer-proposed quantum computing issue descriptions

Note: The initial version of this document was written by Erik DeBenedictis

1. Quantum computers find better solutions to current problems

What problems will quantum computers solve more effectively than classical computers, and how much will it matter to society? For example, there is a well-studied quantum algorithm for factoring numbers that has implications to encryption, and there are quantum computer algorithms for optimization that may find solutions closer to the global optimum than any algorithm on a classical computer.

The group should address the amount society is likely to be changed by the by shifting from classical to quantum computers. For example, could a stockbroker using a quantum computer price stocks more accurately and become more successful than one just using a classical computer? POC: TBD (DeBenedictis)

2. Preparation for Hardware Scale Up

It is obvious that ultimate success of quantum computers will require scale up by similar factors to what has been experienced by semiconductors. Projections of quantum computer scale up are often based on an misplaced interpretation of a paper by Gordon Moore in 1965 ["Cramming More Components onto Integrated Circuits," Electronics, pp. 114–117, April 19, 1965]. Apparently due to the second figure in this article, many people now believe it was about an ongoing rise in integrated circuit component count now called Moore's law. This may be valid for CMOS, but it is not the right interpretation for quantum computers. A careful reading of Moore's article reveals that it is actually about a series of tests, whose results are summarized in the first figure of the article, that validated that factors such as speed, power consumption, reliability, and manufacturing cost vary across successive generations in a way that permits economically feasible scale up of a particular (physical) integrated circuit architecture called the planar integrated circuit. Before quantum computers can be declared "scalable" and subject to Moore's graph, one or more quantum information equivalents to the planar architecture (i. e. qubit types) will need to be devised and assessed to see if the various engineered parameters stay in bounds as each potential architecture scales. The role of IEEE could be to identify, perhaps through a standards effort, the appropriate engineering parameters, form consensus opinion on whether they have been satisfied for each specific physical architecture (e. g. qubit type), and to identify critical research activities that may need additional attention. POC: Scott Holmes, Paolo Gargini

3. What Rebooting Computing could do next?

Rebooting Computing is the IEEE initiative supporting this summit. Rebooting Computing has a conference November 7-9. 2018, for which quantum computing comprises one of three main topics. Last year, IBM announced their 50-qubit quantum computer research achievement at the "Industry Summit" on Friday of the conference week. This year, many quantum computer companies and research projects will be represented.

IEEE would like to be a venue for exciting events in quantum computing, and last year's Rebooting Computing conference was a good start. How do we keep up the momentum? Could IEEE offer the quantum equivalent of a Gordon Bell award or a TOP500 list? POC: Bruce Kraemer

4. New applications

Quantum computers are believed capable of solving problems that are intractable with today's computers, but critics point out that many problems that have been shown amenable to quantum

speedup are not considered important to practice. This should be no surprise. If a certain type of problem cannot be solved, it seems obvious that there will be no big, profitable industry selling solutions to that problem. But what about changes in society? If a quantum computer can solve known but previously intractable problems, perhaps companies will emerge selling new, useful products and then grow to be big and profitable.

Quantum games are an example. These are games with strategies that use quantum information. Some quantum strategies can beat the best possible strategy that relies solely on classical information. Since there are no quantum computers suitable for quantum games today, we have no competitions between quantum computers. However, once suitable quantum computers become available, businesses could compete on the basis of which one has the best quantum computer. If one company could get ahead of another by having a better quantum computer, every company would need one -- irrespective of whether there was any independent benefit to society.

How can IEEE facilitate exploration of this question? POC: TBD (DeBenedictis)

5. Quantum benchmarks

There has been substantial interest in rating progress in quantum computing, yet this requires suitable performance metrics. In fact, IEEE's standards organization has a standards effort to develop such as metric. Without intruding on these standards efforts, how can quantum computer metrics, roadmaps, TOP500 lists, and so forth fit into an overall IEEE strategy. POC: Travis Humble

6. New quantum conferences and publications

Conferences and publications are two of IEEE's most prominent lines of business. What new conferences and publications would be appropriate to support quantum computing? This can be documented as a list of "calls for papers," which can be time-ordered like a roadmap or triggered by events, if appropriate. POC: Elie Track

7. Quantum computer software engineering

Early languages for both classical and quantum computers merely provide bookkeeping assistance for controlling the underlying hardware, such as assembly language for classical computers and gate sequences for quantum computers. However, programming languages for classical computers evolved over time to embrace higher programmer productivity through, for example, object orientation, domain specificity, and team programming methods.

Quantum computers must show quantum speedup to have an advantage over classical computers, and it is known theoretically that quantum speedup requires exploiting some unique features of quantum information, specifically qubit phase, interference, and entanglement.

Can this group provide a vision for quantum programming languages and software that shows an evolutionary path from simple orchestration of gate sequences (gate model) or Hamiltonians (quantum annealing) to a way of raising programmer efficiency as they are harnessing the unique features of quantum information – and preferably when programming in teams. POC: Tom Conte

8. Quantum machine learning and artificial intelligence

There is both a theoretical basis and experimental evidence that quantum computers can learn training sets more efficiently than classical computers. Taken at face value, this would allow quantum computers to learn from self-driving car training sets more quickly than is currently possible with a GPU. However, faster learning will not address the issue that self-driving cars get into accidents that seem due to the limitation of their "intelligence" to pattern recognition.

Can this group create a vision for what concepts a quantum computer might be able to learn that a classical computer cannot, thereby enabling progress in machine learning and AI.

For example, the literature shows how quantum computers can learn by tunneling through barriers in an optimization space, as opposed to just moving downhill, but what types of lessons need to be learned by tunneling instead of descent? POC: ?

9. Quantum roadmap

The traditional semiconductor roadmap, ITRS, has reorganized within IEEE as the International Roadmap for Devices and Systems. IRDS is in the process of developing its first roadmap for cryogenic and quantum computing for release in stages between November 2018 and Spring 2019.

This group can discuss how this roadmap fits into IEEE's overall mission. POC: Scott Holmes, Paolo Gargini

10. Support for other parts of QIS and new technical areas

What is the right scope for IEEE's interest? Quantum Information Science (QIS) is generally considered to comprise quantum computing, quantum communications, and quantum sensors. The US Government is proposing a large research program on QIS. There is also less clearly related area called post-quantum cryptography, which is the study of cryptographic codes that are resistant to being "broken" by quantum computers.

Within quantum computing, there will be specialized areas within IEEE's engineering focus, such as engineering of quantum systems at scale, technology for control systems, education on quantum computing topics, and software for quantum computers.

This summit has been scoped to quantum computing as a tactical suggestion of IEEE. The rationale is that a new project should focus its efforts, but may later grow to encompass a group of logically related issues.

This group can discuss a vision for how IEEE might schedule its interest in the broader set of areas over time, matching IEEE's resources against business risk from overextension and topical interest in the community. POC: Steve Bush

11. IEEE's role in quantum computing education

IEEE is a large part of many student's undergraduate and graduate education and is in a key position to influence and inspire. Some questions to consider:

-Could IEEE suggest courses and/or content to ABET or to universities who are looking to grow this area?

(maybe IEEE could sponsor a “Dean’s Summit” on Quantum Computing and invite university Deans in physics, computer science, and engineering)
-Could IEEE sponsor relevant student competitions?
-Could IEEE offer a certificate in this area? Here’s a link to their certificates program: https://www.ieee.org/education/certificates/index.html
-Can IEEE sponsor Distinguished Lectures in this area? (see, for example, Circuits and Systems society lecturers: http://ieee-cas.org/distinguished-lectures)
If so, perhaps IEEE student branches could invited these lecturers to campus. Many schools do not have expertise in this area, and this would give students an opportunity to see the potential and hear about opportunities. POC: Scott Koziol