Quantum computing for computer scientists pdf file software

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In recent years, quantum computing has shifted from a theoretical exercise to a practical one, as small-scale quantum computers have become increasingly available. This course, which follows a basic course in quantum computing, addresses the practical challenges of programming these emerging devices. To this end, this course is broadly divided into 2 topics: Quantum Compilation â translating high-level descriptions of quantum algorithms into “machine code” suitable for running on quantum hardware and doing related tasks such as optimization and mapping of operations on physical memory locations Quantum algorithms â developing a deeper understanding of standard oracle-based quantum algorithms (aka “90s style”) running on large, (distant) future quantum computers, as well as new families of classic/quantum hybrid algorithms designed to work on noisy intermediate-scale quantum devices (NIS) Q), which more like the small, limited quantum computers of today The course will cover the following topics: quantum circuits and ZX computation Quantum circuit compilation and optimization Hardness and classical simulation of quantum computation Cloud quantum computation Hybrid/variational quantum algorithms Quantum simulation and chemistry This course will be given in person (LTA) for weeks 1-5, and online weeks 6-8. Classes will be held every Tuesday, Wednesday and Friday from 16:00 to 17:00 (full time here). The recordings will appear on Panopto immediately after each lesson. The problem sheets will be a mix of theoretical questions and coding assignments, with the latter date as Jupyter notebook Class information, including weekly deadlines is on Minerva Everything else (problem sheets, material program, etc.) is here on the course website The course consists of: Completing problem sheets The problem sheets encoding are given as Jupyter notebook. Ã you can download and make them on your computer, or you can complete them in your browser using a service such as Google Colab if you are performing on your computer, make sure you get the latest version of Pyzx by performing Pip Install Git+https: //github.com/quantomatic/pyzx. If you run on Colab, click the "Open with Colab" connection next to the problem window. The first time I save, make sure to click File> Save a copy in Drive (you will need a Google account to do it). After this, you work on your copy, so you can save in the normal way. To send the sheet, send the .ipynb file to your teacher. If you have completed the sheet with Colab, click File> Download> Download .iipynb to download the file for sending. Lessons The following is a list of topics covered in the lessons. Since this is the first iteration of the course, the topics of the individual lessons have not yet been aimed. The notes of the lesson for this course are a draft of the next book Picturing Quantum Software, which will be updated regularly for the whole period. It can be downloaded from the material material. Hand written notes will be updated after each lesson: Part 1 | Part 2 | Part 3 | Part 4 | Part 5. Some lessons are equipped with slides, which can be downloaded by clicking on the links below. The collection is also a collection of Jupyter notebooks that cover the last 3 weeks of material. It is highly recommended to download them and to examine them personally before starting the miniProject. Lesson 1, 18 Jan: Introduction to quantum software (slides) Lesson 2, 19 Jan: Quantum theory is Scum Lesson 3, 21 Jan: Circuits and ZX-Diagrams Lesson 4, 25 Jan: The ZX-Valcolo lesson 5, 26 Gen: ZX and CNOT Circuiti Libera Less 6, 28 Jan: Cliffords and States of the graphic Lesson 7, 1 Feb: Simplification of Clifford Diagrams Lesson 8, 2 Feb: strong classical simulation of the Clifford circuits Lesson 9, 4 Feb: Lesson 10, 8 Feb: exponential pauli and gadget pauli lesson 11, 9 Feb: forms for Clifford+phase circuits Lesson 12, 11 Feb: doors and phase of Toffoli Toffoli Dealer.)Evoba Ees(seedils dna seton erutcetsil gniidaer.puk ot strandures please liirwonk roirp eht fo keew tsrif eht deweive tpneic tupuqc roir tuple roir roir roir tuple Hcaorppa ciamimammargaid eht if gnidaar dnuorgkcab era ot degaruneocne era strandures ,esac rettal eht yitamrofni mummtnauq ot noitcuducortni ro b/a trap s noamac srik osla yam stneduts ,revewoH .esruoc siht erofeb noitatupmoC dna sessecorP mutnauQ ekat ot degaruocne ylgnorts era stnedutSsetisiuqererP .puorg mutnauq eht yb deiduts scipot hcraeser tnerruc elkcat ot ydaer eB .smelborp noitalumis mutnauq dna noitasimitpo laciremun evlos ot smhtirogla mutnauq lanoitairav esU .seuqinhcet lacihparg gnisu smhtirogla Mutnauq Desab-elcaro Fo Ssalc Redorb to Dnatsrednu .Wawdrah Mutnauq Fo STNIARTSNOC LACISNOCP ROF TNUCRICRICRICRICRICRICRICRICRICRICRICRICRICRICRICRICRICRICRICRICRICED esimitpo ot relipmoc mutnauq a yb enod snoitamrofsnart yek dnatsrednU .sksat lanoitatupmoc fo yteirav a mrofrep ot stiucric mutnauq gnisisehtnys dna gnitneserper yltneiciffe rof seuqinhcet ylppA .suluclac-XZ eht gnisu stiucric mutnauq yfilpmis dna ,etalupinam ,tneserper yltneulF :ot elba eb lliw stneduts ,esruoc siht gniyduts retfAsemoctuo gninraeL :raM 11 ,42 erutceL :raM 9 ,32 erutceL mhtirogla noitasimitpo etamixorppa mutnauQ :raM 8 ,22 erutceL revlosnegie mutnauq lanoitairaV :raM 4 ,12 erutceL)sedils(stpecnoc gninrael enihcam mutnauQ :raM 2 ,02 erutceL yhpargomot etats Mutnauq dna stnemerusaem :Rram 1 ,91 eructel setts gnisilausiv dna gniiraperp ,81 eruct)Sedils(tiksiq/qmbi ot 2 mutnauq dna noitcartxe tiucric :bef 81 ,51 eutcel cqbm rof msinimreted dna wolf Desilareg :BEF 61 ,41 erutcel gnitocel mutnauq desab-tnemerusem :Beph 51 ,3 | Quantum GroupFeedback students are formally asked for feedback at the end of the course. Students can also send feedback at any time here. The feedback received here will go to the head of the academic administration and to be confidentially treated when it will be transmitted further. All the feedback is welcome. For a long time, the development of quantum computers concerned theoretical and hardware aspects. But while attention moves towards programming, software and security problems, classic IT sciences are returning to the game. It will take special programming languages to correctly exploit the potential of quantum computers. (Photo: Eth Zurich) The physicists had long nourished the ambition to build a quantum computer. In the early 1980s, one of the most famous among them, Richard Feynman (1918 - 1988), wondered if he would ever be possible to efficiently calculate and simulate the phenomena of quantum physics using a conventional computer. He claimed that digital computers could not calculate quite quickly to calculate and simulate the quantum effects that generally occur within atoms and molecules and between elementary particles-allome not in a reasonable period of time. Initially, he proposed to build a quantum computer not based on digital coding but rather on a direct imitation of quantum systems. The main idea of him, who continues to inspire the development of quantum computers to date, was that some properties of quantum mechanics could be exploited for the calculation. In particular, there would mean exploiting two quantum states of particles: overlap and intertwining. The overlap principle, for example, can be exploited by quantum computers to perform faster calculations. While digital computers use bite bits that can only take on states One or zero, quantum computers use quantum bits or quibits, to process information. Qubit can be one or zero and can also be one and zero simultaneously, a state we call we call This crucial difference allows a huge jump in the processing speed for some calculation problems. In the future, quantum computers promise to perform ultra-efficient calculations that normal computers cannot resolve in a reasonable period of time, a stage sometimes defined as quantum supremacy. Although scientists have not yet found conclusive evidence of the existence of quantum supremacy, the recent technical progress have been impressive. In 2019, Google claimed to have achieved quantum supremacy for a specific computational problem for the first time, having built a quantum computer that required only 200 seconds to solve a problem that would have requested a conventional 10,000 -year computer. At this moment, quantum computers are too small and subject to errors to represent a serious threat to digital computers â € today, which are able to perform billions of calculations per second. Even the quantum computer of â € has been able to demonstrate its supremacy only in a single specific task. However, quantum technologies have achieved a phase in which their development is in the hands of more than simple physical. Today, many computer scientists are ã ¢ â € â € Âœquantum Curiousâ ¢ â € Â, according to Kenneth Paterson, professor of computer of the hat. He leads research in the field of encryption and works on sure ways of elaborating, transferring and archiving information. Ã ¢ â € â € ÂœTa â € â € to have been ã ¢ â € Â Â Â Â Â Â Â Â Â Â â Â â € Â € â € in my research area since the quantum calculation has started to become a larger problem in encryption about ten years ago, Ã ¢ Â Â ™ â € â € Â € â € Â says Paterson. It is as soon as someone builds a quantum computer that is sufficiently large and reliable, the current internet encryption framework ceases to be safe, because the quantum calculation could be used to crack that encryption. and security that run behind the scenes whenever we connect to social media, make an online purchase, use online banking or send an email are all based on integer and related factoring which are vulnerable to algorithm. The factorization of the entire Ã is the process of breaking down a large composite into its prime factors. This requires a great amount of computing power, which is why there is not yet an algorithmÂ thisÃ9Â, no calculation procedureÂÂ that a digital computer can use to efficiently solve a factoring problem. In 1994, however, mathematician Peter Shor created a specially designed algorithm for quantum computation, which could find the prime factors of composite integers significantly faster than classical algorithms. The ideas of ShorÃ Âs Âs can be used to crack the other forms of public key encryption in use today. Ã ÂÂWith quantum computers, the encryption used today on the Internet is not Ã9Ã¹ safer.Ã¬ÂÂKenneth Paterson TodayÃ¬Âquantum computers are too small and prone to errors to run the ShorÃÂ Âás algorithm. In principle, however, Ã is clear that any quantum computer that is sufficiently powerful and reliable to do so would be able to perform factorization within a reasonable time. When it occurs this situation, factoring-based encryption and related techniques currently in use will no longer be secure¹. Not all encryption will be influenced, of course; for example, quantum computing does not seriously Â the security of encryption methods that rely exclusively on secret key encryption. But public-key encryption Ã ÂÂ which currently forms the basis for securing over 90 percent of web traffic Ã ④ ÂÂ will be Ã definitely at risk. According to Paterson, a quantum computer would need millions of quantum bits to crack a security key. ETH Zurich scientists currently operate quantum computers with up to 17 qubits. On the front development, researchers are on the verge of reaching a new phase of medium-sized quantum computing systems with 50-100 qubits, although these are still susceptible to errors. Ã ÂÂBut we may see a sudden step forward in the power of quantum computers, and it may take at least ten years to change todayÂÂ todayÂÂ key encryption. That'Â whyÂ Â we're getting ready now,ÂÂ says Paterson. His group has co-developed a new quantum-safe algorithm that is being evaluated in an ongoing worldwide competition to select new quantum-safe algorithms. Sometimes people ask Benjamin Bichsel if he thinks his research will be This was in vain if large-scale, reliable quantum computers were ultimately impossible. Ã ÂÂI think this Âis the wrong question,Ã ÂÂ says. Ã ÂBut I wonder what we do if quantum computers end up working brilliantly and we have a clueÂon how to program them efficiently!Ã¬Â Â Â Â Â   ÂBichsel works in the research group led by computer science professor Martin Vechev, whose group developed the first high-level intuitive programming language level for quantum computing in 2020. Special programming languages will be needed to properly exploit the potential of quantum computers. Â ÂQuantum programming languages are essential for translating ideas into instructions that can be executed by a quantum computerÂÂ Microsoft researchers wrote in 2020 in the scientific journal Nature. Authors include Bettina Heim and Matthias Troyer, who previously worked as researchers at the Institute of Federal Polytechnics for Theoretical Physics. Quantum programming languages Ã Â today are closely linked to specific hardware. These description languages Ã ④ ÂhardwareÂÂ focus on the behavior of circuits and how to optimize them. In contrast, the Silq programming language developed by Martin VechevÂs' group technical details. Ã Â ÂSilq Ã is the first high-level quantum programming language that is not customized mainly for design and functionality hardware, but more for the mind programmers who want to solve ovitavonni ovitavonni otubirtnoc orol li rep igole itangadaug ehcna onos is maet ous li e vehceV nitraM .anretni aznereoc e aznagele aus al rep isnesnoc otatsiuqnoc Âig ah ,ollevil otla id acitsitnauq enoizammargorp id oiggaugnil omirp emoc ;qliS otaicnal otats ¨Ã odnauq ad onna nu osrocsart Ã leshciB nimajneBÂ Â¢Â.amelborp dna ygolonhcet mutnauq ,scisyhp mutnauq evah ew esuaceb ,egatnavda laer a sah hciruZ HTE erehw si sihTÂÂÂ¢ .nosretaP syas ÂÂÂ¢,yltneiciffe smelborp cificeps evlos ot enibmoc stnenopmoc elpitlum hcihw ni metsys retupmoc degdelf ylluf a fo trap hcaorppa wen siht ekam ot deen lliw ew ,ytilaer a gnitupmoc mutnauq ekam ot tnaw yleniuneg ew fIÂÂÂ¢ .swolfkrow dna snoitacilppa mutnauq ,erawtfos mutnauq ,erawdrah mutnauq ,smhtirogla mutnauq htiw dnah ni dnah segaugnal gnimmargorp gnipoleved ot tfihs lliw sisahpme eht ,daetsnI .stsicisyhp yb depoleved erawdrah rof erawtfos dna segaugnal gnitirw stsitneics retupmoc no sucof a fo ssel eb lliw ereht ,nur gnol eht nI .vehceV nitraM syas ÂÂÂ¢,tiksiQ htiw gnitupmoc mutnauq fo ycneiciffe eht sevorpmi noitatupmocnu citamotua ecnis Ylaicepse â€â€TMs tegaugââ ¢ Segaugââ nal Rehto ot tpecnoc qlis tpecnoc yek refsnart nac ews ew taht ees ot ot gnigaruocne yrev sâ€â€â€ rMacnu Chemnu Chenam ã¢vehcev ,emitnae m eht , tub .ria eht ni u Hcum yrev llits â€â€â ylevitcepser ,qric dna tiksiq ,#q â€â€TREE to dloh nac qliS rehtehw fo noitseuq ehT gnitupmoc fo weiv citsiloh A .gnitupmoc mutnauq fo trap yek a seulav yraropmet pu naelc yllacitamotua ot ytiliba eht sekam tahT .ssecorp noitaluclac eht esidrapoej dna seno tnerruc htiw tcaretni yam seulav detaluclac ylsuoiverp taht snaem tnemelgnatne fo elpicnirp eht ecnis ,revewoh ,sretamoc mutnauq fo esac eht your xelpmoc erom tol who kat siht .yromem pu eerf ot yllacitotua desare era erulav eseht ,sutrep . gnitaerc ,spets etaidemretni lareves ni ksat a sessecorp retupmoc A .ÂÂÂ¢yllaunam krow suoidet siht od ot sremmargorp gnicrof naht rehtarÂÂÂ¢ seulav yraropmet teser yllacitamotua ot qliS selbane taht erutaef ÂÂÂ¢noitatupmocnuÂ â€â eht ot strifer ylticil Pxe Erutan ,Qlis Tuoba Elcitra Rehuttruf ni ni reducing reducing errors in quantum resworb out len otatilibasid otats ¨Ã tpircSavaJ .ebolG HTE atsivir alled 30/12 oremun lus osrappa ¨Ã otset otseuQ vehceV nitraM«Ã .ottet ossets ol ottos ottut acitamrofnI

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