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Double-Degree Master's Program in Computational Science: Experiences of ITMO University and University of Amsterdam

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Abstract

We present a new double-degree graduate (Master's) programme developed together by the ITMO University, Russia and University of Amsterdam, The Netherlands. First, we look into the global aspects of integration of different educational systems and list some funding opportunities from European foundations. Then we describe our double-degree program curriculum, suggest the timeline of enrollment and studies, and give some examples of student research topics. Finally, we discuss the peculiarities of joint programs with Russia, reflect on the first lessons learnt, and share our thoughts and experiences that could be of interest to the international community expanding the educational markets to the vast countries like Russia, China or India. The paper is written for education professionals and contains useful information for potential students.

Keywords: teaching computational science; Master's program; double degree; curriculum; enrollment; student research; funding opportunities

1 Introduction: Why computational science? Why now?

In the past decade, Computational Science has become an indispensable tool in all fields of human life: from traditional physics and engineering to biology, medicine, economics, arts, sociology and more "exotic" fields like fashion or criminology. The world turns progressively more digitized and interconnected, with smart phones and smart homes continuously computing something for us, smart systems controlling transportation and production, and early warning and decision support systems protecting our safety and well-being.

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Progress in these smart technologies requires a growing pool of new-wave professionals who can develop models, algorithms and software tools, and then efficiently harness computational resources available in a multitude of hardware and middleware environments (from smartphones and laptops to high-performance clusters, supercomputers, Grids and Clouds). Experts in computational science are highly valued in all research institutions and industrial sectors, but until recently only few universities provided complete coherent educational programmes in computational science, e.g. [1], [2], [3].

The University of Amsterdam pioneered this field by establishing the Computational Science group [4] in 1990 and a Master's program [3] in 2005, first as a track in Computer Science and Grid Computing programs. The Computational Science group led by Prof. Peter Sloot has been collaborating with several Russian research institutes within international projects. These strong ties resulted in a special award from the Russian government for setting up an Advanced Computing Lab [5] at the ITMO University, St. Petersburg, within the Leading Scientist Programme [6]. One of the goals of this program was the development of joint educational and research programs [7].

A great initiative taken by the organizers of the Workshop on Teaching Computational Science [8], held in conjunction with the International Conference on Computational Science [9], brings together researchers and educators to push forward this challenging and exciting branch of science. Joint efforts and strong incentives from high-tech industries helped to promptly establish several new educational programmes in computational science around the world [2], [10], but the curricula and educational methods were often inherited from the existing programmes in computer science and applied mathematics and physics. Establishing an internationally recognized benchmark in Computational Science curriculum could be one of the goals in this Workshop.

In this paper we present a new double-degree Master's programme developed together by the ITMO University, Russia and University of Amsterdam, The Netherlands. First, we look into the global aspects of integration of different educational systems and list some funding opportunities from European foundations (Chapter 2). Then we describe our double-degree program curriculum, suggest the timeline of enrollment and studies, and give some examples of student research topics (Chapter 3). This information may be useful to the prospective students. Finally, we discuss the peculiarities of joint educational programs with Russia, reflect on the first lessons learnt, and share our thoughts and experiences that could be of interest to the international community expanding the educational markets to the vast countries like Russia, China or India (Chapter 4).

2 Global integration of educational systems: Why and How?

2.1 Past, present and future of global education

Globalization and amalgamation of world economies, with strong interdependencies between the countries, have led to gradual integration of the educational systems. The first wave came with the Age of Enlightenment in 17th-18th centuries, which defined the school of thought in Western Europe[1] and spread out to Southern and Eastern Europe, Russia, European colonies in Africa, Asia and America. In the next two centuries, the educational systems developed consistent and compatible programs for primary and secondary education, and started to form the basis of a global higher education. Alas, the two World Wars and the Cold War of the 20th century disrupted the integration process and essentially separated the educational systems of the Western Bloc and the Eastern Bloc. The only positive side of this separation was the extreme competition that boosted higher education (although largely inclined towards the military-driven engineering).

Only the last years of the 20th century resumed the integration process by the Lisbon Recognition

[1] Curiously, British coffeehouses (not to be confused with the modern Dutch "coffeeshops" for smoking marijuana) played a crucial role in scientific exchange and educational reform discussions.

Convention[2] (1997) and the Bologna Process (1999), which created the European Research Area (2000) and European Higher Education Area (2010)[3]. With these new rules and standards, joint-degree and double-degree programs are becoming very popular in higher education. The universities benefit from this model because they can introduce new educational programmes without hiring extra staff, instead offering some courses in partner-universities. The students find it very attractive because they can learn from the best teachers in the field and gain a unique international experience while studying in different countries. Recognizing these benefits, European foundations offer a variety of granting opportunities through Tempus[4], Marie Curie[5], Erasmus and Erasmus Mundus Programmes[6]. A review of the progress made in international student mobility can be found in [11].

2.2 Focus on Russia and BRICS: Why is EU & USA interested?

All successfully developing countries (e.g. BRICS countries) reach a point when they need to adopt the top technologies to progress further. That requires more than just a few highly skilled experts imported from the technologically developed countries; it requires a "mass education". In the past decade China and Russia have entered this phase; now India and Brazil are joining the race. At the same time, Western Europe is aging and outsourcing most industries to other countries, instead concentrating on banking, management and research. These two factors shrink the supply of local students enrolled in the "hard"-science (STEM) programs.

This is a happy point where the demand for top-quality education in developing countries meets the supply of professors and educational programs in the developed world. China was only partly successful in sending their students to top universities (mostly in the States), under the condition that they come back to work in China: most students did not return. Of course the high-tech companies where they land are happy with this fact, but for the Chinese government this method is questionable[7]. Another way to make both parties satisfied is establishing joint educational programs. This is the way we are exploring in the University of Amsterdam, the Netherlands and ITMO University, Russia.

Russian education has been traditionally very strong in hard sciences: mathematics, physics, chemistry, engineering, and informatics. This important tradition from the Soviet times comes together with the highest in the world ratio of highly educated people: 54% of the Russian labor force has attained a tertiary (college) education, according to a 2008 World Bank statistic http://goo.gl/1KcMUr. With this excellent background and a tradition of working hard[8], Russian students are well prepared to take even the most challenging courses in top world universities, that is, if they manage to learn the foreign language (more on that in the next section).

[2] Lisbon Convention on the Recognition of Qualifications concerning Higher Education in the European Region is an international convention of the Council of Europe elaborated together with the UNESCO, ratified by all 47 member states of the Council of Europe. It was also signed by Canada and United States, but not ratified yet.

[3] The Bologna Process strengthened the competitiveness of the European higher education and fostered student mobility and employability. It includes all 47 member states of the Council of Europe. The European Higher Education Area was created to ensure more comparable, compatible and coherent systems of higher education in Europe http://www.EHEA.info

[4] Tempus (**T**rans-**E**uropean **M**obility **P**rogramme for **U**niversity **S**tudies) is the European Union's programme which supports the modernisation of higher education in the Partner Countries of Eastern Europe, Central Asia, the Western Balkans and the Mediterranean region, mainly through university cooperation projects http://eacea.ec.europa.eu/tempus./

[5] Marie Curie Fellowships are European research grants available to researchers regardless of their nationality or field of research. Scientists have the possibility to complete their training with competences or disciplines useful for their careers. http://ec.europa.eu/research/mariecurieactions/

[6] Erasmus Programme (**Eur**opean Community **A**ction **S**cheme for the **M**obility of **U**niversity **S**tudents) is a European Union (EU) student exchange programme. From 2014, *Erasmus+* took over, a new European programme for Education and Training 2014-2020 http://ec.europa.eu/education/opportunities/index_en.htm

[7] As we were finishing this paper, Russian government declared a similar program, fully covering education of 3000 Russian students in top 200 universities http://en.itar-tass.com/opinions/1643 under the condition of coming back to work in Russia. There is one important question though: Does this project still make sense if very few students actually return? Chinese experience shows that the imposed fine cannot solve the problem.

[8] Russian high schools and most universities had a workload of 40 "contact" hours per week in the class plus up to 20 hours homework per week. This load is now reducing, after Russia joined the Bologna Process limiting the program workload.

In 2012, Russia decided to promote 15 Russian universities to the TOP-200, out of which 5 universities should land in the TOP-100 of the world's leading universities according to the QS World University Rankings by 2020. This Program, conveniently called "5-100-2020", has a budget of over 40 billion Rubles (over 1 billion Euro or 1.4 billion US dollars) for the first 3 years (till 2016). Without discussing the pros and cons of this "urgent" desire to be in the international ranking, the top 15 universities, including the ITMO University, have already received the money and are eager to invest in academic mobility and scientific cooperation with the TOP-500 world universities. Joint research projects and educational programs are extremely important in this race, therefore the number of such programs will grow exponentially in the very near future.

2.3 Integration with Russia: Global issues and solutions

We see 4 global issues that may hamper a quick progress in the ranking race: (1) separation of Russian educational system from research institutes; (2) cultural differences; (3) language issues; and (4) partial incompatibility of Russian educational system with the majority of the leading world universities, including those in EU. A few words about each issue and possible solutions:

(1) Russian higher education is traditionally run by the universities under the Ministry of Education, whereas research institutes are run by the Russian Academy of Science. They are disconnected. Some collaboration and a few academicians and researchers teaching in educational institutions only slightly alleviate the problem. This is a fundamental issue that requires a strong political decision and immense wisdom in its implementation. Last year the first steps have been taken in transforming the Academy; that stirred a wave of protests. We can only hope that the merger of education with research will bring more benefits than losses.

(2) The cultural differences are acutely experienced by the students and coordinators of joint Master's programs. Russian education has been traditionally more "rigid", with teachers and supervisors giving precise instructions and requiring exact execution. Combined with the high workload (both in class and at home), this approach gave students very strong qualifications in the subjects they learnt, but as a result students often lack the skills of self-learning and innovative thinking. In recent years, new young teachers appeared in universities, often with some research background. They will gradually transform the old stiff approach into a more open-minded style practiced in European Union and in the States, where students are expected to show initiative and work on their own. Changing the Russian style will take another half-generation because it would be disrupting to dismiss the old professors with a valuable knowledge and teaching experience. As a short-term solution, we can only tell students about these cultural differences and "instruct" them not to wait for instructions in European universities, to enjoy the freedom in selecting research topics and optional courses, and to find their own ways in solving problems.

(3) Most EU countries have launched international Master's programs in English, and most Russian schools are teaching English starting from the secondary education (or primary education in specialized schools), and most Russian universities offer weekly English lessons in the first 2 years of Bachelor programs. But in spite of this, the situation with the language is not as cloudless as we would like it to be. There are two reasons for this: First, the Russian language is very far from the English[9]; and second, Russia has been largely isolated from Western Europe for several generations (roughly, from the Russian revolution in 1917 till the fall of the Soviet Union in 1991 and several years of chaos that ensued). This unfortunate combination explains why even after a decade of somewhat "open" international relations and modernization of Russian education, the English language is still a challenge most of the students are facing –often without even knowing it until they take the TOEFL or

[9] Most countries in Western Europe speak either Latin (Romance) or Germanic languages, whereas Russian belongs to the Slavic branch, very different in structure, grammar, vocabulary and sounds. In addition to Russian, many federal regions have their own co-official languages, often belonging to a completely different language family: Latin (Romance), Germanic and Slavic (Russian) languages belong to the Indo-European family; whereas southern and eastern regions of Russia speak languages from Altiac, Mongolic, Turkic, Uralic families.

IELTS test. Our experience shows that most students enrolled in our Master's program are good in reading, about a half can decently write, but only 10% score high in listening and speaking tests.

The only global solution to this problem would be introducing the English lessons earlier (in primary school or even kinder garden) and increasing the professional level of teachers. Obviously, this will take a long time and lots of efforts on all levels, from government to schools and parents. The short-term solutions for the joint Master's programs could be either introducing intensive language courses, preferably starting on a Bachelor level, or adding an entry requirement of TOEFL or IELTS score only slightly below than that required by the partner-university in EU or USA.

(4) Until recently, the Russian higher education system was incompatible with the Bologna Process: the lowest degree in Russian universities was the Specialist, obtained after 5–6 years of studies. Only in October 2007 Russia enacted a move to the two-tier education model in line with Bologna Process. Transition to real Master's degree will be completed in 2014. The labor market in Russia still regards BSc diplomas as inferior to "classic" Specialist education, thus MSc stage remains mandatory for most graduates. This is a disadvantage to new students, since Master's programs are not free anymore. But it is an advantage for European and American universities, especially since the start of the 5-100-2020 program, where joint or double degrees from foreign universities are greatly valued.

There are smaller related issues with partial incompatibility of the semester periods, enrollment processes and timelines, exam procedures, evaluation systems, grade registrations, credit point workload, exit qualifications, student feedback, etc. All these questions are not fully discovered yet, and the only way to solve them is by trial and error. The second intake of students will have a much better start, after the first students have walked the road and put the sign posts.

While we are now considering just one particular programme between a Russian university and a Dutch university, these global issues and solutions are generic and applicable to all joint educational programs established between EU or USA and developing (BRICS) countries.

2.4 Why University of Amsterdam and ITMO University?

The University of Amsterdam (UvA) was founded in 1632 and today ranks amongst the top 50-100 universities in the world. UvA provides excellent opportunities for multidisciplinary education and research thanks to some of the most advanced computing, networking, storage and visualization facilities in the world. The Faculty of Science at UvA has more than 70 international master programs including MSc in Computational Science [3] run by Professor Sloot's research group [4].

The ITMO University is the leader in informational technologies in Russia and the World Champion in ACM International Collegiate Programming Contest, see Figure 1 and Table 1. In 2010

Figure 1: ITMO University is the World Champion in ACM International Collegiate Programming Contest. Photo courtesy of ITMO University http://en.ifmo.ru/

Wins	Country	Institution	Most Recent
5	Russia	Saint Petersburg State University of Information Technologies, Mechanics and Optics	2013
3	China	Shanghai Jiao Tong University	2010
3	United States	Stanford University	1991
2	Poland	University of Warsaw	2007
2	Russia	Saint Petersburg State University	2001
2	Canada	University of Waterloo	1999
2	United States	California Institute of Technology	1988
2	United States	Washington University in St. Louis	1980

Table 1: Winners of the ACM International Collegiate Programming Contest. ITMO won 5 times. Source: http://en.wikipedia.org/wiki/ACM_International_Collegiate_Programming_Contest

the ITMO Faculty of Information Technology and Programming and eScience Institute won a 150 million Ruble (3.5 mln Euro) grant for setting up an Advanced Computing Lab [5] under the leadership of Prof. Sloot [6].

Within this project, researchers worked together on leading-edge computational science problems in complex networks and dynamical systems [12], [13], [14], in adaptive load balancing for distributed computing [16], in virtual problem-solving environments for semiconductor research [17], in artificial intelligence and finite element models for flood early warning and decision support systems [18], [19], [20]. Another goal of the project was development of joint educational programs. Based on our previous experience [3], [21], [22], we launched a double-degree Master's program in Computational Science and held the first International Young Scientists Conference, which resulted in a special issue of the Journal of Computational Science [7].

The education in Computational Science is supported within various projects of the Russian Government and President. The first program on Supercomputer Education was held in 2010-2012 http://hpc.msu.ru/?q=node/117. More than 40 Russian universities participated in this project and more than 100 courses were designed for Bachelor and Master Programs. It created a strong foundation to train specialists and researchers in Computational Science. In that project the ITMO University played a flagship role in the area of designing international joint educational programs, including our new Double-Degree Master's Program in Computational Science.

The decision to combine efforts in marrying Russian educational system to European standards emerged as a logical continuation of a long-term scientific cooperation of the ITMO eScience Research Institute and the UvA Computational Science group.

The quality of students in ITMO University and their career opportunities.

According to the Report of the Higher School of Economics on quality of students admitted to state universities http://goo.gl/3UVsOH, out of over 650 universities in Russia, **ITMO University is #7 in quality** of the enrolled high-school graduates and **#1 in the number of scholarships** in the field of Informatics & Computer Science (see Table 2).

The main criteria of a program selection for a student are **career opportunities and future salary**. Statistics of salary offers in Russia –based on over 2 million open positions collected from a hundred job search requests in websites Superjob.ru, HeadHunter.ru, Rabota.ru, Job.ru– shows that the highest salary is offered in engineering positions with higher education in Applied Mathematics, Computer Science and ICT. In St. Petersburg, an entry-level engineer earns about 1000 Euro/month, 30% higher than an HR of finance specialist, and nearly 2 times higher than a shop assistant or other vacancy not requiring higher education. With an average monthly salary in Russia of 26822 rubles [23] (around EUR 600), ITMO graduates can earn twice as much, working as researchers, programmers, web-designers and alike. The **demand for master programs in ICT and Computational Science steadily grows** and appears a lucrative undertaking for potential students.

#	University	Average grade of enrolled students (max. 100 points)	Number of scholarships
1.	St. Petersburg State University	92.5	32
2.	Moscow Institute of Physics and Technology	92.3	11
3.	Higher School of Economics, Moscow	91.7	111
4.	Novosibirsk State University	88.0	75
5.	National Research Nuclear University, Moscow	87.4	148
6.	Russian Presidential Academy of National Economy and Public Administration, Moscow	86.0	16
7.	**ITMO University, St. Petersburg**	**84.9**	**269**
8.	Higher School of Economics, Nizhny Novgorod	83.9	16
9.	Financial University under the Government of the Russian Federation, Moscow	83.1	61
10.	Voronezh State University	81.9	84

Table 2: Average grade of enrolled students (based on the Unified State Examination) and the number of state-funded scholarships in the Informatics & Computer Science programs in 2013. Source: Report of the Higher School of Economics on quality of students admitted to state universities http://goo.gl/3UVsOH

One of the competitive **advantages of our double-degree Master's program** from ITMO University and UvA is its novelty and uniqueness. This program will teach students to build computational models from real life observations, to turn these models into computational codes and to perform large-scale simulations. These skills are in high demand in Russian and foreign companies, both in industry and academia. A Master's degree from a TOP-100 university gives extra opportunities to go for a PhD in prestigious universities or to work in international corporations, where Russian degree would not mean as much as a degree from the University of Amsterdam.

Above all, studying in The Netherlands is a happy and exciting experience for Russian students. Dutch people are very open and friendly with foreigners, and the University of Amsterdam is oriented towards international students and offers a number of services and support facilities to ensure smooth and pleasant stay and efficient study process.

3 Double-degree Master's programme "Computational Science in Multidisciplinary Research"

In 2012, the University of ITMO and University of Amsterdam launched a double-degree Master's program "Computational Science in Multidisciplinary Research". The program takes **two years** and gives **120 ECTS** credits. During the first year (60 ECTS) students study at ITMO University, and the second year (60 ECTS) they spend in UvA. The credits earned in the partner university are mutually recognized by the other partner. In the end, students defend their master thesis and obtain **two Master's degrees**: from UvA and from ITMO.

The two **prerequisites** are as follows: (1) Bachelor's degree in the field of computational science or equivalent, completed with good grades; and in UvA (2) Sufficient proficiency in the English language. The minimum score required on the TOEFL Internet-based test (iBT) is 90, IELTS test: 6.5, and a Cambridge Examination Score with a minimum test result of CAE A or B http://goo.gl/lzLtCn.

The **education in ITMO is free**. Good students receive a small stipend and in addition have a chance to work in research projects and earn money sufficient for independent living in the Netherlands. The tuition fee in UvA is 1835 Euro for our program, 10 times lower than a regular fee for foreign students outside of the European Union, thanks to the support from the board of the UvA.

In addition to the regular studies, the students participate in the annual **Young Scientists Conferences** http://acl.ifmo.ru/?ws=15 and in **Summer Schools** organized by UvA and ITMO together with the SkolTech and MIT. The next two-week summer school will be held in July 2014 in Amsterdam and in St. Petersburg http://goo.gl/vm24kW.

3.1 Curriculum

Competencies. According to the Bologna Process, Russian education is moving towards a competency-based system. Our courses are covering three levels of competencies:
(1) Social and personal competencies in communication, ethics, linguistics, teamwork, etc.
(2) General scientific competencies in mathematics, natural sciences, economics, etc.
(3) Professional competencies specialized in the area of Master's degree, organizational skills, etc.

Core Courses in the first semester (see Table 3) develop the basic knowledge and skills in the field of applied mathematics and informatics, parallel computing technologies, and software development. **Core Courses in the second semester** lay the foundation for modeling and simulation in various fields of science and teach to apply mathematical theory in development of scientific software applications. The first year courses are taught in ITMO.

The English language courses. Most Russian students, especially those specializing in STEM fields, have difficulties with the English language. To help them preparing for the studies in UvA, two additional courses are given in the first semester: Academic English and Scientific Writing in English.

Elective Courses in the third semester are taught in UvA. They specialize in one of the application domains like computational biology, finance, or earth sciences. The students may also take some courses from other UvA programs if that will help them in their research project. **The fourth semester** is fully devoted to the Master's research project conducted either in UvA or in ITMO.

	The First Semester (ITMO)	ECTS	The Second Semester (ITMO)	ECTS
The first year	1. Applied Mathematics and Informatics	6	1. Continuous Mathematical Models	6
			2. Discrete Mathematical Models	6
	2. Parallel Programming Technologies	6	3. Probabilistic Mathematical Models	6
	3. Modern Informational Theory	6		6
	4. Mathematical Models of Software	6	4. Models and Methods of High Performance Computing	6
	English language courses:		5. Design and Analysis of Algorithms	
	1. Academic English	3		
	2. Scientific Writing in English	3		

	The Third Semester (UvA)	ECTS	The Fourth Semester (UvA or ITMO)	ECTS
The second year	Five of the elective courses:		Master's research project (30 ECTS)	30
	1. Complex Systems Simulation	6		
	2. Evolutionary Computing	6		
	3. Scientific Visualization and Virtual Reality	6		
	4. Geoinformatics and Geoecological Systems Simulation	6		
	5. Bioinformatics	6		
	6. Computational Finance	6		
	7. Forensic Informational Systems	6		
	8. eScience Infrastructures	6		
	9. Non-linear Economic Dynamics	6		

Table 3: Curriculum of the double-degree Master's program in Computational Science. Credit points are given in the European Credit Transfer System (ECTS)

3.2 Timeline of enrollment and studies

The total duration of the program is 2 years, see Figure 2. The program starts in September. The admission process in ITMO begins in March and closes on June 25. Foreign applicants who need a student visa should submit their documents before April 1. To enroll in ITMO University an applicant should pass an entrance interdisciplinary exam in the first half of July.

To enroll in the University of Amsterdam a prospective student should fill in an application form before February 1 next year, submit the results of an English language test (TOEFL or IELTS) before May 1, and provide the transcript of records in July. Students are then enrolled in UvA in July and receive the residence permit and visa before July15. After that the students register for the first-block courses 4 weeks before the start of the second academic year, i.e. by the end of July. The "UvA introduction week" helps the students to prepare for their studies by offering lectures and crash courses and organizing Amsterdam city tours and night parties.

In the end of the second year, students have to defend their Master's theses. The option to submit the thesis only in English, without a Russian translation, is one of the many unique features of our program in Russia. The united examination board consists of the supervisors and experts from both universities, and from the representatives of other institutions and business organizations. A link to the potential employers is a relatively new requirement introduced by the third-generation educational standard of the Russian Federation.

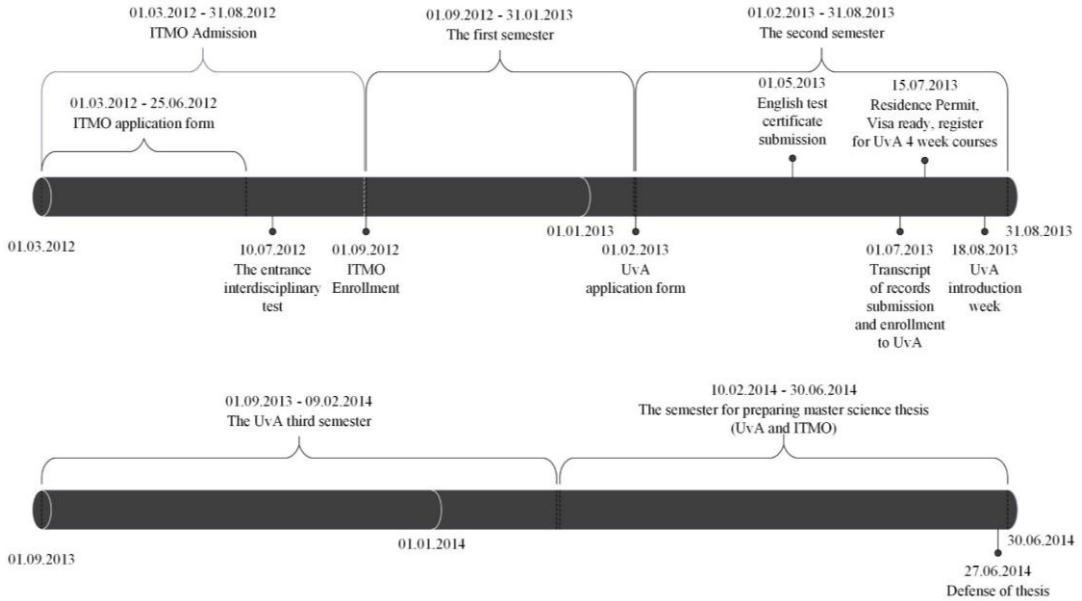

Figure 2: Timeline of the ITMO-UvA double-degree Master's program. Dates are given for students starting in September 2012.

3.3 Research topics of Master's projects

The students select a research topic for their Master's project from one of the many application domains of Computational Science. They usually solve applied real-world problems, developing software that utilizes high-performance computing resources and e-Science infrastructures. That may include data assimilation and processing (including Big Data), decision support systems, or Urgent Computing applications [24] with dynamic control over the computational resources (data, software packages, computing power) in a distributed environment [16]. The students are working in big

research projects [5], [15], [20], [25], and in the business sector, where innovative ICT technologies are actively implemented and used [26]. Some of the research topics of the first Master students and their brief descriptions are given below.

1. **Real-time estimation of workflow execution time in cloud computing environments**. The aim of this work is to find appropriate methods and techniques to create software systems that can adaptively estimate application execution time. Estimation is based on previously obtained historical data and on the real-time status of workflow execution.
2. **Genetic algorithms in modeling relativistic jets from massive black holes**. Magnetohydrodynamic flow processes (i.e. fluid dynamics with relativity and magnetic fields) are modelled for the jets from black holes. Each solution gives a new jet model with a different spectrum, which will be compared to experimental data. With thousands of possible solutions, smart methods and algorithms are required to choose an optimal model best describing the jet. In this study, genetic algorithms will be applied to optimize the choice of solution.
3. **Study of the news spread among social network users with respect to their stakeholdership**. The goal of this work is statistical data analysis from social networks, such as burst size for different kinds of reactions (positive, negative, and neutral); correlation between the user activity level and the type of his reaction. For example, we can suggest that the users with neutral reaction are less active than with positive/negative reaction.
4. **Finding vulnerabilities of criminal systems by complex network modeling**. Fighting organized crime has been an important task of the police forces for a long time. Yet there is still no definite answer on how, having different sorts of information about the structure of a given criminal system, police can most effectively affect the system. This project works with the information collected by the Dutch police about various members of a criminal network, their roles and connections. The goal is to build a working imitational model of this system and to find an algorithm to identify the most critical members of the network, targeted removal of which will disrupt the criminal network.

4 Program implementation status and the first lessons learnt

The first students were enrolled in the summer of 2012, now they are working on their Master theses. 17 students came from 7 regions of Russia and from Kazakhstan. Unfortunately, only four students scored sufficiently high grades in TOEFL test and were admitted to UvA for their second year. They have completed successfully the courses they selected in UvA with the grades of 8.0 and 8.5 (out of 10). All the other students will receive only one degree, from ITMO University.

It was a hard lesson for the international program, and we took this lesson seriously, introducing two additional courses in English for the second group of students enrolled in 2013. Since all additional teaching falls on the shoulders of the same teachers/researchers (without extra pay or reducing other load), this practice shall be a one-time effort to keep the program going. A better solution would be to impose an entrance requirement on English test in ITMO, equal or slightly lower than that in UvA. This is however a disputable option, since legally Russian universities cannot request that yet.

A serious problem related to the group split-up is the "double" load on teaching staff: while a few students study in Amsterdam, another few shall be taught in St. Petersburg, and ideally the same courses that UvA is teaching, to fit the prescribed curriculum. Alternatively, the students have to be moved to a different program and merged with another group, which is also very difficult or impossible in some cases.

After the second admission campaign in the summer of 2013, 18 students (including one student from China) have been enrolled in ITMO University. At the date of this paper submission, most of

them have completed the courses of the first semester, except of the additional English courses, where 3 students failed and a few students were at the threshold. All successful students are now filling in the pre-application forms to register in UvA for the second year of the program.

This hints at another inconvenience: *double* degree means two enrollment procedures, two thesis in two languages, two supervisors, and two thesis defenses. It all strains the students. There are two ways out: First, to convert the program into a *joint* degree, where just one set of procedures is necessary and only one degree is given jointly by two universities. That, however, is far from straightforward due to the many legal and bureaucratic constraints. The second option is to alleviate the hurdles as much as possible. We have managed to cut down two trees so far: (1) we will accept a Master thesis in one language (English) with a summary in Russian; and (2) we will organize just one thesis defense procedure (also in English), where two Master Exam Committees will be present: from UvA and from ITMO.

5 Conclusions and future work

The trend towards global integration of the world economies inevitably leads to **integration of educational systems**. A special attention goes to the BRICS countries, which are eager to study in the best world universities, by all means. A brief discussion of Why and How given in this paper should have convinced the reader. There are however **global issues** that shall be tackled to make the joint educational programs successful, most notably (1) separation of Russian educational system from research institutes; (2) cultural differences; (3) language issues; and (4) partial incompatibility of educational systems. While the first hurdle might be only Russia-specific, the last three are definitely present in most other developing countries. While global solutions are possible in the long run, we discussed also some short-term solutions that could be implemented with a careful planning.

Based on a long-standing collaboration between the University of Amsterdam, The Netherlands and ITMO University, Russia, we have launched a **double-degree graduate (Master's) program in Computational Science**. The bigger part of this paper can serve as a Program curriculum description and a source of useful links and action points essential for successful studies. Some examples of student research topics and scientific framework projects could inspire future scholars.

There are still many **open questions** in the program organization, for instance in case of a group splitting into those who come to Amsterdam and those who stay in St. Petersburg. The curriculum is also changing every year, both in UvA and in ITMO; therefore fixing the program in the agreement between the universities was not the smartest idea, which we will have to correct now.

A lot of work is being done, and much more is to be done in the future to comply with ever changing environment and competition. We have set very audacious **goals**: *to make our master program internationally recognizable and to ensure that our graduates stand out from the crowd in the job market worldwide*. Studying abroad, learning from the top experts in the field, working in real-world projects and taking internships in leading IT companies will make our Master's programs very attractive to Russian students, and perhaps to a wider audience. Already this summer Russian teachers, who raised the World Champions in programming, will be giving an intensive course in parallel programming to the European students during the Summer School http://goo.gl/vm24kW.

In 2014 ITMO University **plans** to open **two more international Master's programs**: "Urban Supercomputing" and "Big Data and Extreme Computing", in partnership with UvA and Technical University of Catalonia, Spain http://www.upc.edu under the Erasmus+ Programme. Another direction of future work is formalizing a **joint PhD degree** between UvA and ITMO. We already have three PhD students who have been doing a collaborative research under the joint supervision from UvA and ITMO, and who shall defend their PhD theses in August 2014. But under current Russian rules, the future doctorates will prefer to defend their thesis in UvA, rather than go for additional bureaucratic

procedures and translation of their thesis into Russian. This way, ITMO and Russia at large are investing resources into the honor of another university and another country.

One final comment, after looking at the topics of the Workshop on Teaching Computational Science: we have noticed that there are barely any **female students** in Computational Science in UvA, while in ITMO we now have 4 females in a group of 15 students. This is not much compared to the non-STEM sciences, but much more than Computational Science attracts in UvA. It is too early to do any analysis, but it would be very interesting to find out if (and why) Russian females find Computational Science more attractive than EU females, especially given the fact that Russian Comput*er* Science (IT and programming) also attract very few females (1 in 10 or even 20). Is that the cultural differences? or linguistic? or the drive to study abroad suppresses the fear of programming? In a few years we will know.

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