SAPIENZA
Università di Roma
Facoltà di Scienze Matematiche, Fisiche e Naturali

Master in
La scienza nella pratica giornalistica
A. A. 2016/2017

European FET Research Projects on High Performing Computing and Quantum Technologies: Analysis of the Online Communication Strategies

Masterizzando
Dott. Giulio Mazzolo

Docente Guida
Dott. Daniela Ovadia

Direttore
Prof. Isabella Saggio

Abstract

This thesis presents an analysis of the online communication activity of EU-funded research projects in Future and Emerging Technologies (FET) within the Horizon 2020 programme. In particular, it focuses on the use of the Twitter platform by FET projects in high performing computing (HPC) and quantum technologies (QT).

FET projects were found to be present on disparate social media. More than 95% of the projects have created a website. The most used social networks are: Twitter ($\sim$ 50% of the projects), Facebook ($\sim$ 20%) and LinkedIn ($\sim$ 15%). Finally, the analysis suggests that the number of online channels considered by each FET project is not strongly influenced by the available budget, but rather by the pursued communication strategy.

HPC projects are among the most socially active initiatives within the FET environment. In particular, roughly 80% of them have created a profile on Twitter. Among HPC projects, the average posting rate is of the order of one tweet per week. The Twitter activity of HPC initiatives is typically comparable to that of the FET profile in terms of *i*) number of account's tweets retweeted by other users, and *ii*) average number of shared links per tweet (approximately 30% and 0.4, respectively). Currently, the most influential HPC projects on Twitter have roughly more than 100 followers and a ratio between followers and followed accounts larger than 2. Finally, conversations mentioning HPC projects were found to be extremely viral and capable of reaching hundreds of thousands of users.

Contrarily to HPC projects, no QT initiative has created an account on Twitter. An analysis was performed to estimate the potential reach of QT projects on this social platform. The investigation was based on the amount of mentions of specific hashtags. The result indicates that QT projects may reach a Twitter community comparable to that of HPC initiatives.

Key words: science communication, high performing computing, quantum technologies, Future and Emerging Technologies, Horizon 2020, social media.

Contents

Synopsis

This thesis is divided into two parts. Part I (chapters 1 and 2) presents and overview of the importance of science communication in modern society and a description of the Future and Emerging Technologies (FET) science funding programme of the European Union. This part is not based on original of the author. Part II (chapters 3 - 5) presents the analyses performed by the author and the results. A summary of each chapter is provided below.

Part I: Introduction

Chapter 1: The role of science communication This chapter highlights the societal importance of science communication. The main items discussed in the chapter are: *i*) the knowledge era, *ii*) societal and economical challenges of the knowledge era, *iii*) the scientific citizenship as a solution to the challenges of the knowledge era, and *iv*) science communication and its role for the creation of a democratic information society.

Chapter 2: FET in Horizon 2020 This chapter describes the FET funding programme and two of its research lines: high performing computing (HPC) and the development of quantum technologies (QT). The main items discussed in the chapter are: *i*) the Horizon 2020 funding programme, *ii*) the FET programme as part of Horizon 2020, and *iii*) the HPC and QT efforts of the FET funding initiative.

Part II: Analysis and results

Chapter 3: FET projects and social media This chapter analyses the presence of FET projects on online social media. The main items discussed in the chapter are: *i*) the fraction of FET projects active on the considered social platforms, *ii*) the comparison of the presence of HPC and QT projects on social networks, and *iii*) the impact of the budget available to projects on the number of online channels activated for science communication campaigns.

Chapter 4: HPC projects on Twitter This chapter investigates the activity of HPC research projects on Twitter. The main items discussed in the chapter are: *i*) the analysis of the statistics collected from the Twitter profiles of the FET HPC initiatives, *ii*) the identification of the most influential projects, and *iii*) the virality of the Twitter conversations mentioning FET HPC projects.

Chapter 5: The Twitter potential reach of QT projects This chapter presents an estimate of the community reachable by QT projects if they were active on Twitter. The main items discussed in the chapter are: *i*) the spread of hashtags representative of conversations on HPC and QT projects, and *ii*) the comparison of the aforementioned statistics to assess the Twitter audience interested in QTs.

This work was done under the supervision of Dr. Daniela Ovadia.
Questions and comments to be sent to giulio.mazzolo@gmail.com.

Part I

Introduction

Chapter 1

The role of science communication

This chapters presents a concise overview of the importance of science communication in modern society. Section 1.1 outlines the characteristics of the knowledge era. Section 1.2 focuses on the related economical and societal challenges. Section 1.3 highlights the need for scientific citizenship in the knowledge era. Section 1.4 presents science communication as a requirement for the acquisition of the scientific citizenship.

1.1 The knowledge era

Three economical eras have been identified in the history of human civilisation. The first one was the agricultural era. This is believed to have started between 10000 and 8000 B.C. in different regions in the world [1,2]. The second one is the industrial era. It began in England in the 18th century as a result of the industrial revolution [3,4]. The third one is the knowledge era, and it is the age into which human civilization is currently entering [5].

The three eras are based on different primary production resources. The agricultural age was founded on the work of people and animals. The ultimate source of richness and development in the industrial era was the work of people and machines. Finally, the current era is not based on the capacity to produce and store tangible goods, but rather on the ability to accumulate, generate and apply new knowledge [6].

The knowledge on which the current era is based is mainly scientific. In the past centuries, the impact of science on humanity has been growing without interruption [7]. Nowadays, the outcomes of scientific activities permeate our society and life style. Examples range from telecommunications to medicine, or from artificial intelligence to the development of new materials.

The reason for the increasing impact of science is the peculiar nature of scientific knowledge as a resource [8]. Like any other resource, it is important for the capacity to provide solutions to problems. However, contrarily to resources such as water, food or oil, scientific knowledge is potentially unlimited, as it is capable of generating itself (knowledge leads to new knowledge). Moreover, the same knowledge can be used simultaneously by multiple entities. Hence, scientific knowledge is intrinsically a non-exclusive good.

For its characteristics as a resource, scientific knowledge has revolutionised the world economy. The current science-driven change of the global market has introduced countless positive innovations. However, it has also led to dramatic societal changes.

1.2 Challenges in the knowledge era

The relationship between scientific research and society has changed significantly after the Second World War. From the second half of the 20th century, several countries have started using science and its generation of new knowledge and technology as a source of economical growth. This process has progressively become more intense over the last decades. Nowadays, nations invest significant fractions of their gross domestic product in research and development. Examples are the European Union, the United States, and Asiatic countries such as China and South Korea, see figure 1.1.

The capacity of scientific knowledge to generate richness has

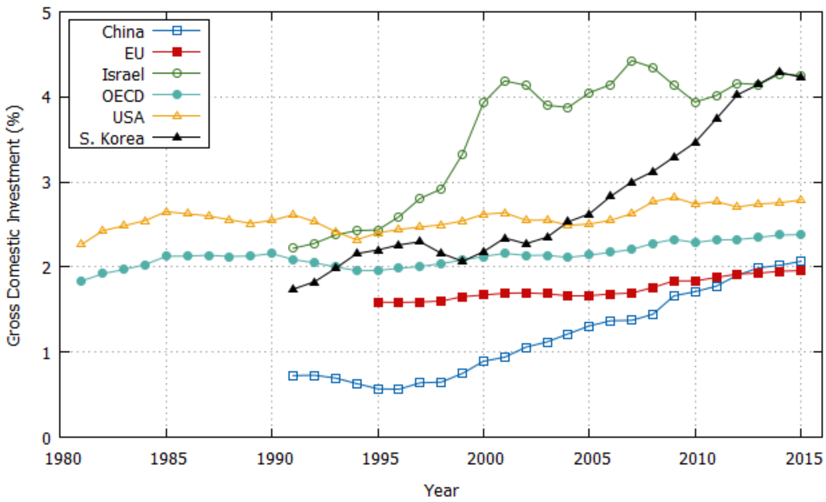


Figure 1.1: Percentage of the gross domestic product invested in science and development over the past years by some of the world's leading economies. The image is based on data of the Organisation for Economic Co-operation and Development (OECD) [9].

attracted a growing number of private investors. As a result, in many countries private investment on scientific research is larger than public funds [10]. One example are the United States, where the former is currently twice as large as the latter [11].

The leading role of private investors is based on a reinterpretation of knowledge as a resource. To pursue personal profit, investors are typically non interested in sharing the knowledge they develop or they way they use it to create goods. This approach limits the possibility to generate new knowledge from the results of others. Moreover, people with limited buying power cannot afford specific classes of products and benefit from the knowledge behind them. One example are patented expensive medicines [13]. In such a scenario, knowledge as a resource partially looses the intrinsic characteristics mentioned in section 1.1 of being unlimited and non exclusive.

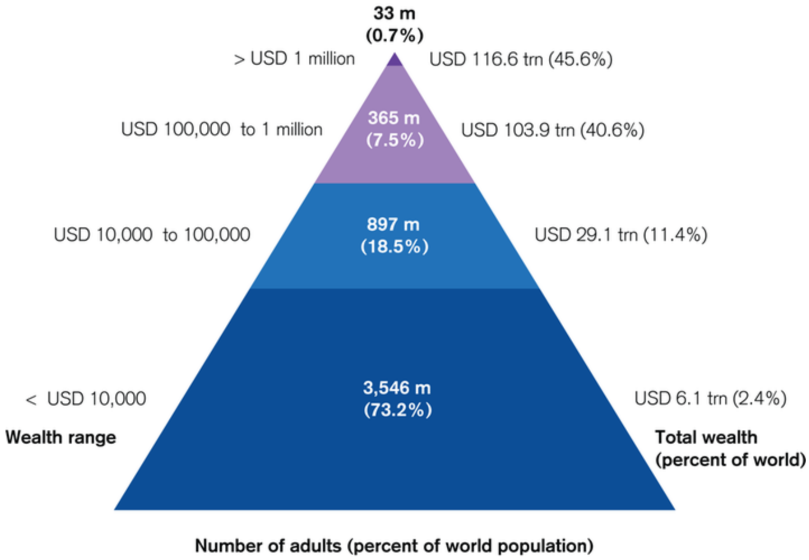


Figure 1.2: Distribution of the global wealth among the world's population. Original image in [12].

The current knowledge-driven development of the global economy has two important consequences. First, humanity is richer than ever before [14]. Second, the progressive concentration of the generated richness in the hands of few individuals is causing societal inequality, see figures 1.2 and 1.3.

The increasing inequality is an obstacle for the creation of a democratic society [15]. The scenario humanity is facing can change if knowledge will not be used as a mere instrument of power, but rather as a common good everyone should benefit from. This paradigm shift can be achieved through the acquisition of the scientific citizenship.

1.3 The scientific citizenship

The potential of scientific knowledge to be a pillar of democratic societies was first recognised by the English philosopher Francis

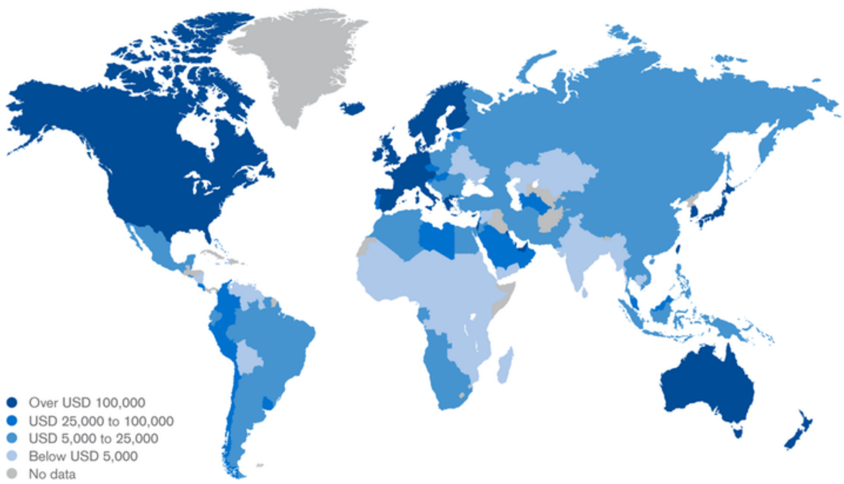


Figure 1.3: Comparison among nations of the current annual wealth per adult. Original image in [12].

Bacon in the 17th century. He proposed that science and technology should not bring advantages to a limited number of societal groups or nations, but rather to the whole humankind [16]. This vision is efficaciously outlined in his utopian novel *The New Atlantis*.

Bacon's ideas are extremely topical. As mentioned in section 1.2, the equal access to goods generated by scientific research is fundamental to prevent societal divisions and exclusions.

A second ingredient for the creation of a democratic society is the people's awareness of the scientific process, as well as of its goals, outcomes and limits [17]. In fact, democratic societies are founded on the engagement of citizens when decisions impacting the community must be taken. Because of the permeating role of science in today's society, science-related issues are no exception [18]. Examples are topics such as mandatory vaccinations, euthanasia, abortion, animal experimentation, alternative medicine, nuclear energy, recycling and, in general, the public investments on research assigned by policy makers. Hence, a better understanding of science is a key factor to ensure effective participatory processes [19].

The population's engagement in decision-making processes is only fruitful if scientific innovations are neither passively accepted nor irrationally feared. To this aim, people must be given the ability to intervene in an informed, rational and critical way. This scenario is only possible if individuals are formed and trained in an adequate cultural context. In other words, if people acquire the so-called scientific citizenship [20].

How to best prepare individuals to become scientific citizens is still debated [21]. Nevertheless, a key ingredient has been identified in the need to bring scientists and citizens closer to each other. It is widely accepted that the construction of a democratic knowledge era depends crucially on the continuous dialogue and information and knowledge exchange between these two communities. A paradigm which motivates the growing importance of science communication.

1.4 Science communication and modern society

Science relies heavily on communication. Research is only useful if communicated to the rest of the scientific community. This has become even more crucial in the era of Big Science [22]. Modern physics offers illustrative examples in this direction. Large-scale experiments such as the LHC particle accelerator at CERN in Switzerland or the LIGO-Virgo gravitational-wave observatories in the USA and Italy are built and maintained by international collaborations of thousands of scientists from tens of different countries [23–25]. These titanic efforts can only be successful if supported by effective internal communication.

The relationship between science and communication has evolved with the transition to the knowledge era [26]. Nowadays, science communication can no longer happen exclusively within the scientific community. As outlined in section 1.3, the construction of a democratic society requires the engagement of disparate societal groups in the decision-making processes related to scientific questions [27]. Examples are scientists, policy makers, private investors, non-governmental organizations, the general public etc. When discussing with each other, these groups make use of science communication.

The aforementioned societal groups have different cultural background and objectives. Thus, they adopt different languages when talking about scientific issues. Moreover, to be effective, each group must tune its science communication on the targeted audience, with the optimal choice depending on both the content and the considered communication channel. As a consequence, numerous different kinds of science communication can be identified.

This thesis focuses on science communication aiming to inform citizens on a non-technical level of current investigation lines. This is the oldest type of science communication not confined within the scientific community. The first example in this direction was the *De Rerum Natura* by the Roman poet Lucretius in the first century BC. Another milestone in this direction was Galileo Galiei's *Sidereus Nuncius* in the 17th century. Galilei's work spread all over the world short after publication and revolutionised humanity's self-perception by propagating the author's innovative astronomical discoveries [28].

More specifically, this thesis focuses on research projects financed by the European Union within the Future and Emerging Technologies programme and on their use of the web 2.0 social media to communicate results and objectives. As outlined in the next chapters, the ultimate goal is to investigate whether European scientists are properly exploiting today's most effective communication channels to inform citizens of two very important scientific challenges: high-performing computing and the development of quantum technologies.

1.5 Chapter summary

In this chapter, the following items have been discussed:

1. Human society is currently entering the so-called knowledge era. This age is characterised by the fact that scientific knowledge has become one of the most important sources of wealth.

2. The knowledge era offers unprecedented opportunities to improve the quality of people's life. However, it also presents new societal challenges. In particular, the unequal access to scientific knowledge and technology may prevent the realisation of democratic systems.

3. The construction of a democratic society in the knowledge era depends on the engagement of citizens and stakeholders in the debate about the impact of scientific issues on their lives. This can be achieved by training people to discuss scientific questions in a constructive and critical way, i.e., by helping individuals acquire the so-called scientific citizenship.

4. One key factor to help people acquire the scientific citizenship is science communication. There exist disparate kinds of science communication, depending on the interacting societal groups. The present thesis focuses on science communication conducted via social media to inform citizens of EU-funded research projects.

Chapter 2

FET in Horizon 2020

As discussed in chapter 1, science communication plays a major role in the development of democratic societies. This is particularly true in the case of publicly funded research. Informing non-scientists of scientific investigations supported with public funding fulfils not only the need for the acquisition of the scientific citizenship, but also the citizens' right to know about the use of tax money. For these reasons, EU-funded research projects invest part of their budget in communication activities.

This thesis presents an analysis of the online communication strategies followed by research projects financed by the European Commission within the Future and Emerging Technologies (FET) initiative, a branch of the Horizon 2020 funding programme. In particular, it compares the communication efforts of two FET research lines: the design of high-performing computers and the development of quantum technologies. The analysis and the results are presented in the second part of the thesis, whereas a description of the FET programme and of the aforementioned research lines is given in this chapter.

The chapter is structured as follows. Section 2.1 illustrates the Horizon 2020 initiative. Section 2.2 provides a description of FET in the framework of Horizon 2020. Sections 2.3 and 2.4 summarise the FET effort towards the development of high-performing computers and quantum technologies.

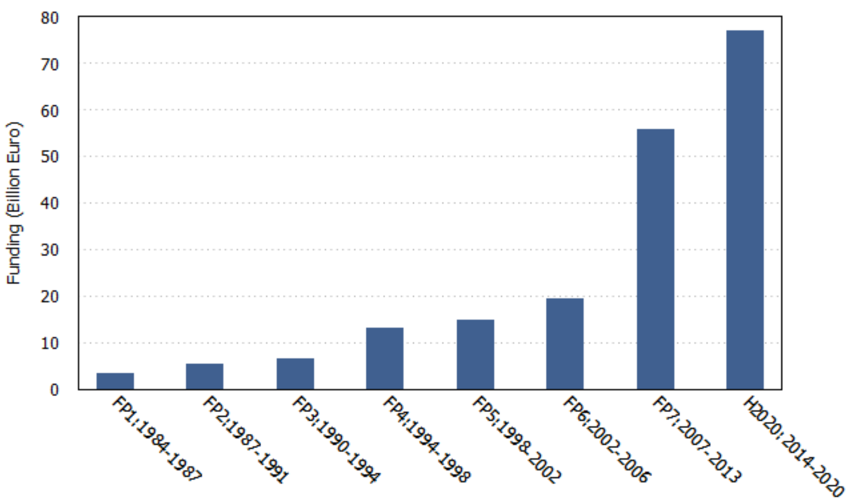


Figure 2.1: Duration and allocated budget of the European research and innovation programmes (also known as Framework Programmes, FP). Data from [34].

2.1 The Horizon 2020 programme

Horizon 2020 is the biggest research and innovation programme funded by the European Union to date. It targets a sustainable societal and economic growth via the development and application of scientific research. The available budget totals nearly €80 billion over a seven-year period (from 2014 to 2020) [29].

Horizon 2020 is Europe's eighth research and innovation programme in chronological order [30–33]. The first one was launched in 1984. Duration and allocated budget of each research and innovation programme are shown in figure 2.1.

Any natural or legal persons (e.g. universities, research organisations and companies) can apply for Horizon 2020 funding. Applications must fit into one of the following categories:

- **Excellent Science:** this initiative supports the excellence of European scientific research on a global level and in a variety of fields [36].

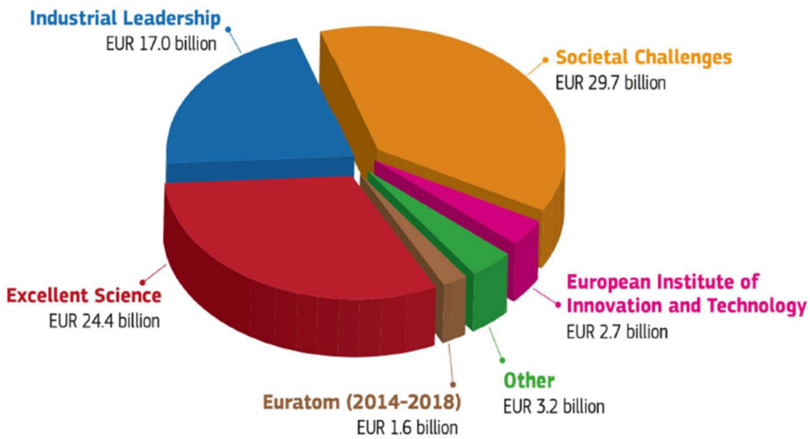


Figure 2.2: Budget breakdown of the Horizon 2020 programme. Original image in [35].

- **Industrial Leadership:** this class of projects targets the development of technological innovations for the future market and the growth of European small and medium enterprises [37].

- **Societal Challenges:** this category focuses on priorities of the European society such as health, education, food and energy supply by combining knowledge and methods from disparate scientific fields [38].

- **European Institute for Innovation and Technology:** this institute is an independent European body promoting synergies in the fields of education, research and business [39].

- **Euratom:** this pillar funds nuclear research in the framework of the decarbonisation of the energy supply [40].

The Horizon 2020 budget breakdown into the aforementioned lines of action is shown in figure 2.2.

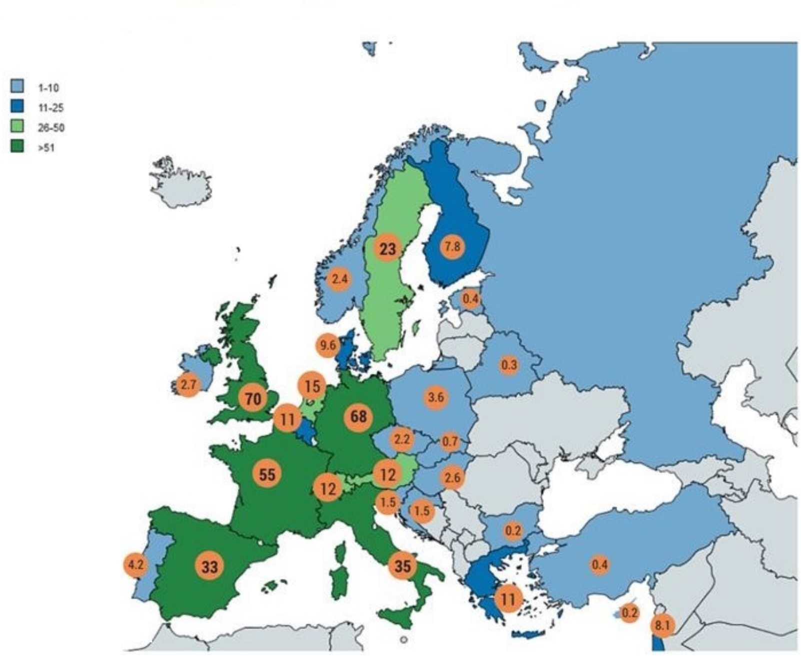


Figure 2.3: Participants in the Horizon 2020 FET programme on a country basis as of June 2016. The numbers correspond to FET funding in million Euro. The colours indicate the number of participants. Adapted from image in [41].

2.2 The FET programme

As mentioned in section 2.1, one of the Horizon 2020 initiatives is the Excellent Science programme. This line of action supports researchers and institutions developing new science and cutting-edge technology. The goal is to keep European research at the forefront of scientific innovation and discover applications to improve the citizens' life and ensure economical growth. Excellent Science is based on the following pillars:

- **European Research Council:** it distributes funding in every research field to single scientists and with the requirement of scientific excellence [42].

Line of action	Estimated final budget
ERC	13.1
FET	2.7
MSCA	6.2
RI	2.5

Table 2.1: Estimated final budget breakdown of the Excellent Science initiative. ERC stands for European Research Council; FET for Future and Emerging Technologies; MSCA for Marie Skłodowska-Curie Actions; RI for Research infrastructure. Budgets are in billion Euro. Data from [35].

- **Future and Emerging Technologies (FET):** it finances collaborative research exploring visionary and radically new investigation lines [43].
- **Marie Skłodowska-Curie Actions:** this initiative assigns grants to researchers at any stage of their career and encourages mobility between countries and fields of expertise [44].
- **Research infrastructure:** it promotes the creation of transnational networks of research infrastructures as well as the training of qualified staff [45].

The estimated final budget breakdown of Excellent Science is reported in table 2.1.

This thesis focuses on the online communication activity of the FET projects funded within Horizon 2020 by the time of writing. The list of these projects is available in appendix A. The distribution of projects participants per country as of June 2016 is shown in figure 2.3.

The FET programme comprises three calls for applications: FET Open, FET Proactive and FET Flagship [46–48].

FET Open

The FET Open call is not bound to one specific investigation theme. However, submitted research proposals must satisfy the following "gatekeepers": scientific and technological breakthrough; foundational; novelty; high-risk; long-term vision; interdisciplinary.

FET Open promotes the Coordination and Support Actions (CSA) as well. These aim at identifying and fulfilling the optimal conditions for FET-related collaborative investigation. One CSA type of action is the FET Innovation Launchpad. This explores possible economical and societal applications of FET results [49]. The list of Horizon 2020 projects funded within the FET Innovation Launchpad action is reported in appendix B.

FET Proactive

The FET Proactive call nurtures synergies on specific research lines by bringing together scientists from interdisciplinary fields. The considered research lines are not ready for the market yet.

Currently, FET Proactive comprises three calls related to "Boosting emerging technologies" and three under "High Performance Computing". Given its relevance for this thesis, the "High Performance Computing" FET Proactive call is illustrated in section 2.3.

FET Proactive invests resources also in identifying investigation roadmaps, designing and distributing material for educational purposes and disseminating FET results among interested stakeholders.

FET Flagship

FET Flagships are Europe's main research effort. They are large-scale, decade-long projects with budgets totalling one billion Euro each. The ultimate goal is to shed light on key scientific themes and apply the results to European society. To date, three FET Flagships have been approved in the Horizon 2020 programme:

- **Human Brain Project**, targeting groundbreaking steps forward in neuroscience [50].
- **Graphene**, exploring graphene's properties and possible applications [51].
- **Quantum Technologies**, aiming to develop innovative technologies based on the laws of quantum physics.

The Human Brain Project and Graphene Flagships started in April 2016. The Quantum Technologies Flagship will start in 2018. Given the relevance of quantum technologies for this thesis, a concise description of the motivations and objectives behind their development is available in section 2.4.

2.3 FET and high-performing computing

Current and future scientific and engineering challenges require increasing levels of computational performances. The demand can be satisfied via the construction of large computer clusters and the development of suitable programming languages. The former provide higher computational power for parallel calculations, the latter an optimal exploitation of the clusters' resources. The use of such practices is known as high-performing computing (HPC) [52].

In terms of increasing computational power, one major HPC goal is the transition from the peta- to the exascale. This corresponds to the increase from 10^{15} floating point operations per second, i.e. the limit of present-day most powerful supercomputers, to 10^{18}. The upgrade to the exascale is motivated by its major impact on all scientific fields over the next decades [53].

As mentioned in section 2.2, the FET HPC research line is funded within the "High Performance Computing" Proactive call [54]. This call comprises three initiatives: *i*) co-design of HPC systems and applications; *ii*) transition to exascale computing;

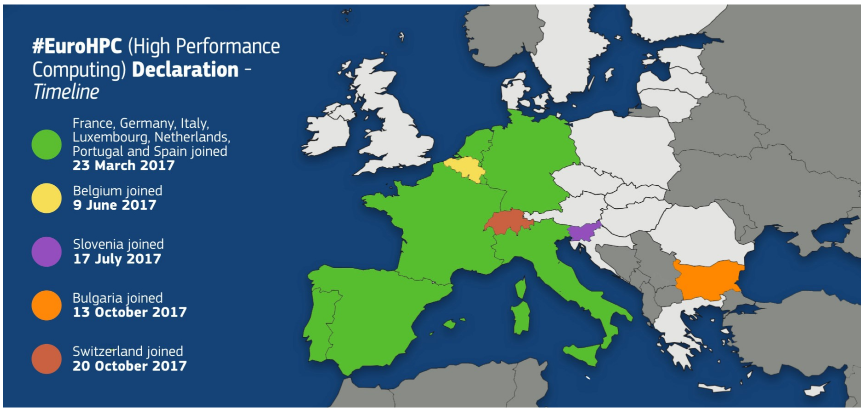


Figure 2.4: European countries signatories of the EuroHPC declaration as of October 2017. Adapted from image in [55].

and *iii*) exascale HPC ecosystem development. The main goals of the three initiatives are to develop the next-generation exascale high-performing computers and to provide access to the resources offered by these supercomputers. The list of Horizon 2020 FET projects active in HPC is available in appendix B.

The FET "High Performance Computing" call is only part of the overarching European effort for the development of HPC. One major initiative in this direction is EuroHPC, a transnational framework aiming to construct two supercomputers based on European technology by the beginning of the next decade [56]. The EuroHPC infrastructure and its computational resources will be available to disparate kinds of communities, such as researchers, industry and the public sector. The creation of the European HPC ecosystem is endorsed by the countries in figure 2.4, signatories of the EuroHPC declaration [57].

2.4 FET and quantum technologies

Quantum technologies arise from applications of quantum physics. They are an important research topic on a global level for their potential to revolutionise human society.

The so-called first quantum revolution started at the beginning of the past century with the development of the quantum theory. The growing understanding of the atomic world led to the birth of new disciplines, such as informatics and microelectronics, and to the construction of countless fundamental tools and electronic devices. Examples range from computers and cameras to lasers and photocopy machines. The first quantum revolution played a key role in starting the knowledge era of human society.

It is believed that the second quantum revolution will be driven by the ability acquired by humankind to actively engineer the quantum world to its own purposes [58]. This is expected to lead to a complete new class of technologies which would reshape our society. One example is the development of quantum computers. If successfully developed, such machines will be far more powerful than any present and future computer based on classical architectures [59]. The urge for Europe to stay at the forefront of the second quantum revolution is outlined in the so-called Quantum Manifesto [60].

The development of quantum technologies is a central objective of the FET programme. The list of Horizon 2020 FET projects in this field is reported in appendix B. Their activity is supported by the ERANET Cofund in Quantum Technologies, a FET Proactive initiative fostering synergies and partnerships among researchers and other stakeholders [61]. Finally, as mentioned in section 2.2, one dedicated flagship initiative will be launched in 2018.

2.5 Chapter summary

In this chapter, the following items have been discussed:

1. Horizon 2020 is the largest research funding programme of the European Union. It is planned to run from 2014 to 2020 and has a total budget of nearly €80 billion.

2. One branch of Horizon 2020 is the Future and Emerging Technologies (FET) programme. The FET call finances visionary research projects targeting scientific breakthroughs and the development and application of radically new technologies. The estimated FET final budget will total nearly €3 billion.

3. One central goal of the FET initiative is the design of high-performing computers. This investigation line targets a power increase in modern supercomputers of three orders of magnitude (from 10^{15} to 10^{18} floating point operations per second). The upgrade from the peta- to the exascale will provide unprecedented computational resources in practically all scientific fields.

4. Another major effort of the FET programme is the development of quantum technologies. In particular, a FET Flagship on quantum technologies has been approved in 2016 by the European Commission and will start in 2018. Allocated funds sum up to €1 billion.

Part II

Analysis and results

Chapter 3

FET projects and social media

As outlined in chapter 2, FET is one of the major funding programmes of the European Union. Launched in 1984, it supports visionary research in a number of disparate scientific fields. Examples range from nanotechnologies to biology and from artificial intelligence to renewable energy.

For the societal benefits discussed in chapter 1 and to boost market uptake, FET-funded projects are required to invest part of their budget in communication activities. The communication channels offering the widest potential audience are based on the world wide web. Examples are websites and social media. For this reason, online channels are pillars of the communication strategies pursued by FET initiatives.

This thesis investigates the online communication activity of FET projects financed within the Horizon 2020 programme, with focus on those active in the development of high-performing computing (HPC, see section 2.3) and quantum technologies (QT, see section 2.4). The analyses are presented in this and in the following chapters.

This chapter gives an overview of the presence of FET projects on online communication platforms. Section 3.1 describes the analysed sets of projects. Section 3.2 lists the communication channels considered for this thesis. Section 3.3 illustrates the search for the channels activated by each FET project. Sections 3.4 and 3.5 provide an overview of the usage frequency of online channels made by FET initiatives. Sections 3.6 and 3.7 investigate the impact of the projects' budgets on the number of considered online communication channels.

3.1 Data set

The list of FET projects launched within Horizon 2020 was downloaded on 15 July 2017 from CORDIS, the main portal of the European Commission on results of EU-funded research projects [62]. It consists of 151 projects and it is available in appendix A. For each project, appendix A reports budget and start and end date as well. FET projects approved after 15 July 2017 were not considered in this thesis.

Some projects in the list were not taken into account for the analyses in this thesis. The excluded groups comprise the Flagship and Launchpad projects (see section 2.2 for a brief description of these two classes of initiatives), as well as projects started after 1 February 2017. Disregarded projects are listed in appendix B. This procedure reduced the data set from 151 to 130 samples.

Flagship projects were not considered due to their budget. The funding at their disposal is significantly larger compared to the other FET projects, see appendix A. The Human Brain and Graphene Projects have therefore more resources to invest in communication activities. For this reason, the two initiatives were not considered representative of FET projects and excluded from the analyses.

Launchpad projects were disregarded as their ultimate goal is to find market applications of results achieved by other FET initiatives. Their interest in communication activities is therefore limited. Moreover, the available budget is relatively small (of the order of hundred thousand Euro), strongly reducing the possible communication effort.

Projects started after 1 February 2017 were disregarded as the time between this date and the data collection was considered insufficient to fully develop and launch an adequate communication activity. The only exception is the DEEP-EST project. In fact, DEEP-EST counts on the online communication channels activated for the previous stages of this initiative, namely the DEEP and DEEP-ER projects, see [63].

Some of the investigations in this thesis required a division into three groups of the data set of 130 projects. The first group consisted of the 22 projects active in HPC. The second group included the 10 projects in the field of QT. The third group comprised the 98 other projects. The lists of HPC and QT projects are reported in appendix B.

It must be borne in mind that the analyses presented in this thesis have been performed on small data sets. The low number of projects indicates that some results may show limited robustness under small changes in the data. Hence, the results in this work should serve as guidelines and are not meant to lead to strong conclusions.

3.2 Considered communication channels

The following communication channels were considered for this thesis:

Website Websites are the online channels offering the highest degree of freedom. They allow the owner to personalise the content, its presentation strategy and the graphic visualisation.

Facebook Facebook is the most used social media worldwide. It offers direct interaction among users and it is mainly designed for free time.

Twitter Twitter is very effective for concise communication. It requires high posting rates and offers less personal interaction compared to Facebook.

YouTube YouTube is the world's main platform for video sharing. It provides a very direct communication channel. However, it is not very effective at engaging users.

Instagram Instagram has a very active and rapidly growing community. It requires content with high visual impact and offers limited interaction among users.

LinkedIn LinkedIn is designed for professional content and enables the creation of closed groups. Nevertheless, the interaction among users and the outreach within the groups are limited.

ResearchGate ResearchGate offers the possibility to share technical documentation and engage in scientific discussions with researchers. As members are mainly scientists, the reachable community is significantly smaller and more homogeneous compared to other social networks.

3.3 Search for channels

A search was performed to determine the channels considered by the FET projects of interest for this thesis. To this aim, projects were contacted and asked on which channels they were active. Only original accounts created by the projects were taken into account. Private or institutional accounts used for project-related communication were not considered.

In many cases it was not possible to find the contact details of the projects or no answer was received. This happened for 38 out of the 130 projects of interest for this thesis (more specifically, for 4 out of 22 HPC projects, 1 out of 10 QT projects and 33 out of 98 other projects). In such cases it was assumed that the links available on the projects' websites pointed to all related accounts on social media. However, for 6 out of 38 projects no website was

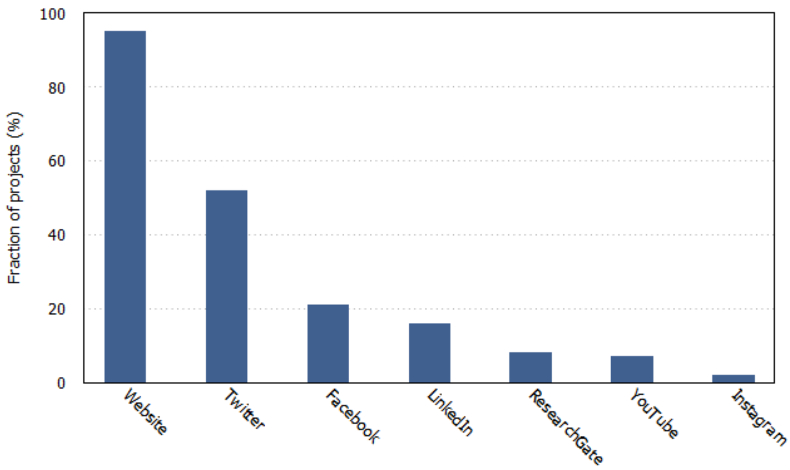


Figure 3.1: Fractions of FET projects funded within the Horizon 2020 programme making use of the communication channels considered for this thesis.

found. To calculate conservative results, it was assumed that no online channel had been considered by these projects by the time of writing.

The list of websites and accounts found by the search is up-to-date as of October 2017 and available in appendix A. It cannot be excluded that the search failed to find all channels activated by the investigated projects. Hence, the list of accounts in appendix A may be incomplete. The results presented in this thesis must therefore be considered as inferior limits when describing the actual scenario.

3.4 Overall use of channels

Different approaches can be considered to estimate the presence of FET initiatives on online communication channels. One quantitative approach is based on the fraction of projects active on specific platforms.

Out of the 130 projects in the data set, 124 have created a website, 67 have opened an account on Twitter, 27 on Facebook, 21 on LinkedIn, 10 on ResearchGate, 9 on YouTube and 3 on Instagram. The results, expressed as a percentage, are reported in figure 3.1.

The analysis shows that almost all FET projects have created a website. Facebook and Twitter are the two most popular social media within the FET community, hence reflecting the scenario experienced in society. Nevertheless, the fraction of projects active on Twitter is larger than that on Facebook. This is opposite to what occurs in society, where Facebook is the most used social media. The result indicates that Twitter is considered a more suitable tool for scientific communication.

YouTube and Instagram are not common communication channels among FET projects. This is probably due to the difficulty of collecting content with high visual impact and suitable for drawing attention of disparate audiences on the project's activity. The difficulty arises from the fact that objectives and results of FET research are often very technical and not appropriate for image-based communication. In the case of YouTube, there is the additional complication of the resources needed for the production of high-quality videos.

ResearchGate is also characterised by a low usage rate. The result indicates that this social media is not seen as a suitable channel for large-scale communication activity. The reason could be the reachable audience, which is typically limited to researchers active in similar investigation fields.

3.5 Online presence breakdown

The analysis in section 3.4 was repeated for the projects in the groups outlined in section 3.1: HPC, QT and the others. This enabled a comparison of how disparate classes of FET projects make use of online communication channels. The amount of projects in each group active on the considered channels is available in table 3.1. The results expressed as a percentage are shown in figure

Channel	HPC	QT	Other
Website	22	10	92
Twitter	17	0	50
Facebook	5	1	21
LinkedIn	5	1	21
ResearchGate	1	0	9
YouTube	3	0	6
Instagram	1	0	2

Table 3.1: Number of FET projects funded within Horizon 2020 making use of the communication channels considered for this thesis. Results are given as a function of the three projects' groups: high-performing computing (HPC, 22 projects), quantum technologies (QT, 10 projects) and the 98 other FET projects taken into account for the analysis.

3.2.

As already indicated by the results in section 3.4, figure 3.2 shows that basically all FET projects have created a website, regardless of the considered group. As for the most used social platforms within the FET community, i.e. Twitter, Facebook and Linkedin, the HPC class shows the largest fraction of opened accounts compared to QT and other projects. The result suggests that HPC projects have established one of the strongest online presences among FET initiatives.

The QT group seems to follow the opposite strategy. The fraction of projects making use of social media is significantly smaller compared to HPC and other FET projects. In particular, none of them has opened an account on Twitter, the most used social platform within the FET community.

The limited use of social media made by QT projects highlights two facts. First, the QT Flagship will design its future online communication activity without guidelines based on previous experience from the same investigation field. Second, classes of projects facing similar challenges in terms of result communication and engagement of non-expert audiences may opt for very

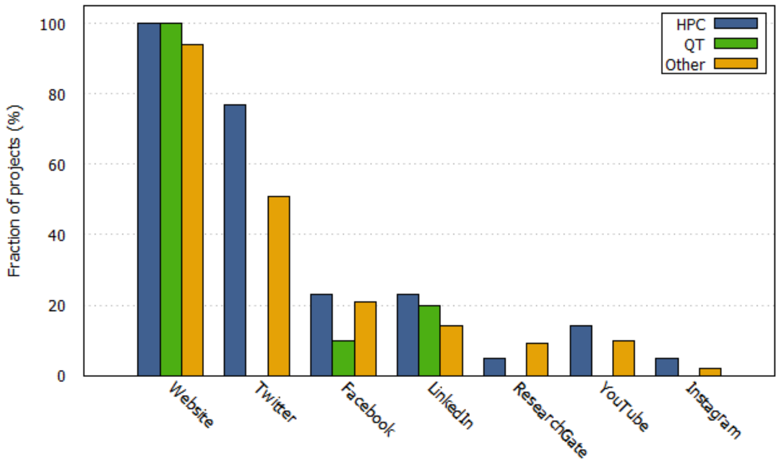


Figure 3.2: Fractions of FET projects funded within the Horizon 2020 programme making use of the communication channels considered for this thesis. Results are given as a function of three projects' groups: high-performing computing (HPC), quantum technologies (QT) and the other FET projects taken into account for the analysis. No QT project is active on Twitter, ResearchGate, YouTube or Instagram.

different strategies. This is the case of HPC and QT projects, which pursue very technical and often interconnected objectives, such as the common goal of improving current computers[1].

3.6 Budget impact

The number of channels considered by the projects depends mainly on the pursued communication strategy and the available bud-

[1] Although both HPC and QT projects focus on the development of present-day computers, the strategies followed by the two groups are very different: the former aims at improving current classical architectures, the latter at exploiting a completely new approach based on the laws of quantum physics, see sections 2.3 and 2.4.

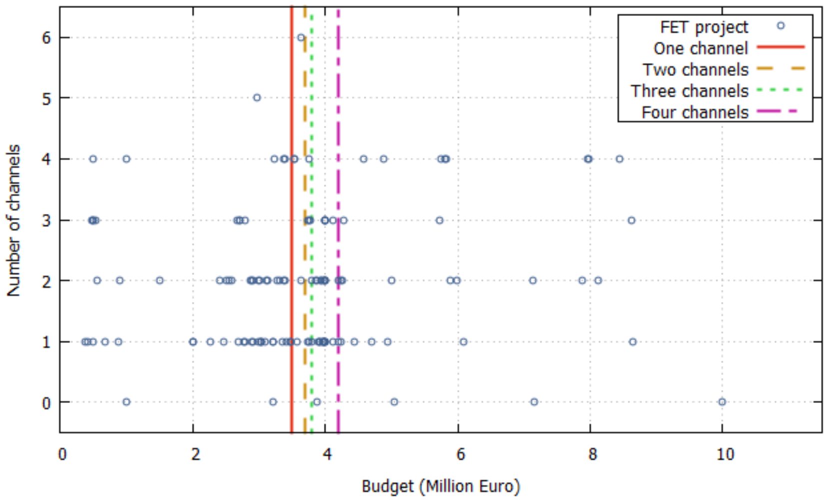


Figure 3.3: Projects' distribution as a function of the available budget and of the number of considered online communication channels. The vertical lines are the budget medians of the groups of projects with one, two, three or four active channels. For the sake of clarity, the figure shows the budget range up to €11.5 million. The following projects were used for the medians calculation but lie outside the plotted budget range: DEEP-EST (€15.9 million, three channels), FLAG-ERA II (€18.3 million, two channels) and QuantERA (€40.5 million, three channels).

get. The two factors are interconnected, as the latter impacts the former. Thus, it is worth assessing how deeply the online communication activity of FET projects is influenced by the allocated funding.

One approach in this direction consists of searching for the dependence of the number of channels on the available fund. To this aim, the following analysis was performed. First, projects were distributed on a plane as a function of the budget and of the number of channels, see figure 3.3. As the plot shows, the majority of the projects has activated a number of channels between one and four. Hence, four groups of projects were considered,

Number of channels	Budget median
One	3.5
Two	3.7
Three	3.8
Four	4.2

Table 3.2: Medians of the projects' budgets as a function of the number of channels considered by the projects. Values are rounded and expressed in million Euro.

based on the amount of activated channels (from one to four). The other projects were disregarded for the analysis presented in this section due to their limited number. For each of the four groups, the median of the corresponding projects' budgets was calculated. The median was preferred to the arithmetic mean as it is a more robust indicator in the presence of outliers. The values are reported in table 3.2 and drawn as vertical lines in figure 3.3.

The analysis suggests a weak correlation between the number of active channels and the budget. On one hand, the larger the median, the higher the number of channels. On the other hand, the variation between the median values is typically of the order of percent. Moreover, it must be borne in mind the the data on the budget correspond to the total available funding, and not to the fraction allocated for communication purposes. Hence, in absolute terms of funding, and remembering that budgets are distributed over the project's duration (some years), the differences are not significantly large. The result indicates that the number of considered channels is not strongly influenced by the budget, but rather by the pursued communication strategy.

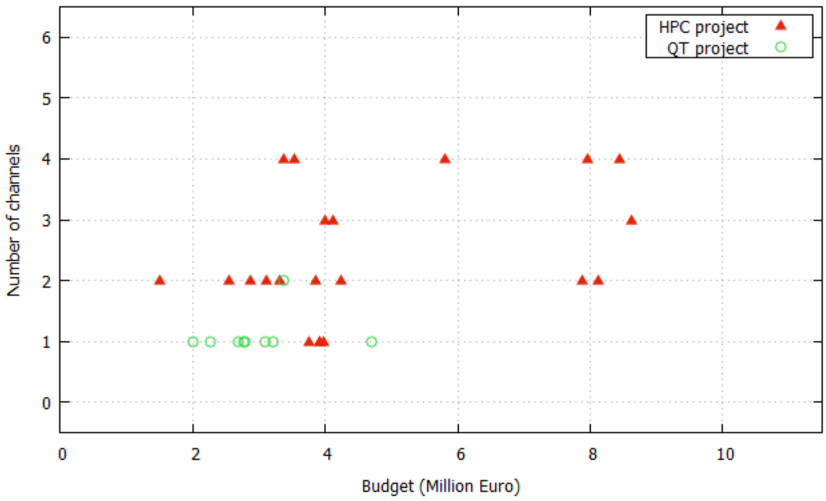


Figure 3.4: Distribution of HPC and QT projects as a function of the available budget and of the number of considered online communication channels. For the sake of clarity, the figure shows the budget range up to €11.5 million. The QuantERA project (€40.5 million, 3 channels) lies outside the plotted budget range.

3.7 Budget impact: the case of the HPC and QT projects

The approach followed in section 3.6 enabled a further comparison of the communication strategies followed by HPC and QT projects. Figure 3.4 shows the distribution of the projects in the two classes as a function of the budget and of the number of active channels. Typically, QT projects lie in the range between €2 and €4 million and have one active channel. HPC projects in the same budget window have typically considered more communication platforms. The result highlights the different communication strategy followed by the two classes of projects, as discussed in section 3.5.

3.8 Chapter summary

In this chapter, the following items have been discussed:

1. FET projects make use of disparate online communication channels. The most used channels are websites, Twitter and Facebook. Only a very limited fraction of projects is active on channels based on visual content such as YouTube and Instagram.

2. The number of considered channels depends strongly on the class of FET project. HPC projects are among the most active initiatives. On the contrary QT projects have very limited presence on the social platforms considered for this thesis.

3. The available budget has a limited impact on the number of active channels. Thus, the amount of social platforms considered by the projects depends mainly on the pursued communication strategy.

4. The indication in the previous point holds for the HPC and QT classes. An analysis of the projects within the same budget range shows that the two groups tend to follow opposite strategies. In general, HPC projects are present on several channels, whereas QT initiatives limit their online communication to the use of the website.

Chapter 4

HPC projects on Twitter

As shown in chapter 3, Twitter is the most used social media among FET projects. In particular, roughly 80% of the HPC projects (17 out of 22) have created a profile on Twitter. This percentage is larger than the corresponding value calculated for the other FET projects. Nevertheless, the result is insufficient to determine how active HPC projects are on Twitter.

An analysis of the Twitter HPC profiles was performed to assess their activity and influence. The results were integrated by a further analysis, based on the monitoring of the mentions of HPC projects on Twitter over a period of three and a half months. The goal of this second analysis was to estimate the virality of the conversations on the considered projects.

Both analyses are described in this chapter. Section 4.1 provides an overview of the past activity of the HPC Twitter profiles. Section 4.2 identifies the most influential HPC projects. Section 4.3 describes the monitoring of the mentions of HPC projects. Section 4.4 ranks HPC project in order of virality of their mentions.

4.1 Overall activity

The past activity of the Twitter accounts of HPC projects was analysed with the Twitter Analytics Tool Twitonomy [64]. For

Project	Date of first tweet	Tweets	Tweets per day	Tweets retweeted	Times per retweeted tweet	Links per tweet	Hashtags per tweet
ALLScale	26/05/2016	39	0.08	15%	1.67	0.72	0.38
ANTAREX	25/09/2015	24	0.03	37%	1.56	0.63	0.04
COMPAT	01/10/2015	122	0.16	7%	1.63	0.30	0.05
DEEP-EST	19/05/2014	900	0.72	40%	2.08	0.52	1.59
ECOSCALE	17/10/2015	19	0.03	21%	1.25	0.26	0.00
EuroLab-4-HPC	-	0	0	0%	0	0	0
ExaFLOW	27/10/2015	389	0.54	24%	1.63	0.62	0.97
ExaNeSt	29/11/2015	1 059	1.54	13%	1.38	0.46	0.06
ExaNoDe	20/06/2017	38	0.32	13%	2.60	0.21	0.03
EXDCI	30/03/2016	864	1.53	16%	2.90	0.20	0.23
EXTRA	06/10/2015	4	0.01	0%	0	0.25	0.25
INTERTWINE	28/11/2016	99	0.31	52%	2.18	0.77	0.79
MANGO	03/12/2015	32	0.05	44%	1.93	0.38	0.38
Mont-Blanc 3	06/02/2012	2 506	1.21	24%	2.68	0.32	0.50
NEXTGenIO	30/09/2015	211	0.28	24%	3.02	0.14	0.52
READEX	13/10/2015	29	0.04	69%	1.60	0.62	1.03
SAGE	30/09/2015	92	0.12	33%	1.77	0.20	0.07
FET	07/01/2016	3 199	4.94	32%	4.46	0.42	0.92

Table 4.1: Statistics collected from the Twitter accounts of the HPC projects funded in Horizon 2020. The data were collected from the date of the projects' first tweet to 14 October 2017. Tweets per day is the average number of tweets posted each day. Tweets retweeted corresponds to the fraction of the project's tweets which have been retweeted by other accounts. Times per retweeted tweet refers to the average number of times a retweeted post has been retweeted. The last two columns report the average number of links and hashtags per project's tweet. The statistics collected for the Twitter profiles used by the DEEP-EST and Mont-Blanc 3 projects include the activities of the previous phases of these initiatives as well, namely the DEEP and DEEP-ER projects and the Mont-Blanc and Mont-Blanc 2 actions. The EuroLab-4-HPC project has posted no tweets since the creation of the account. The last row refers to the @fet_eu profile of the FET funding programme. For this account, the statistics are limited to the maximum number of most recent tweets returned by Twitter (3200). Data were collected with the Twitter Analytics Tool Twitonomy.

each profile, data were collected from the project's first Tweet to 14 October 2017. The statistics extracted for each project are listed in table 4.1. The results of the analysis are outlined in the following subsections[1].

Tweets per day

Out of the seventeen considered HPC Twitter profiles, three have an average tweeting rate larger than one post per day. The time distribution of the tweets of the accounts with the highest average rates are shown in figures 4.1 and 4.2. The tweeting rate is lower than one every second day for twelve profiles. One project has posted no tweets since the creation of the account.

The median of the projects' rates is 0.16 tweets/day. This corresponds to roughly 5 posts per month. The median was chosen as representative value of the HPC posting rate for its robustness in the presence of outliers, see also section 3.6.

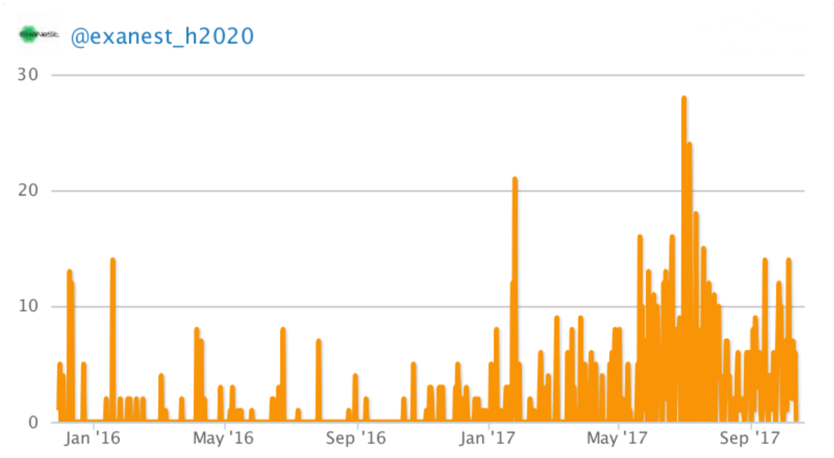
Retweets

The fraction of an account's posts retweeted by others offers an estimate of the effectiveness of the user's activity on Twitter. The higher the percentage, the more the profile is considered a valuable source of information by the Twitter community.

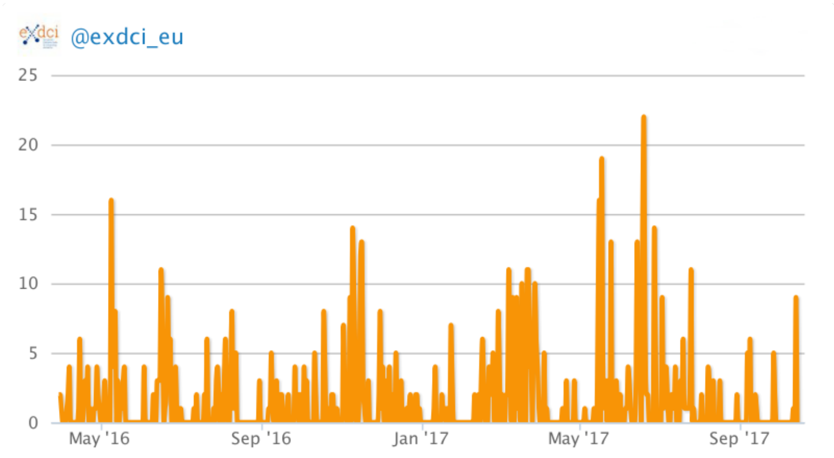
The HPC project with the largest fraction of tweets retweeted by other accounts is READEX ($\sim 70\%$). Except for one, all other profiles have a percentage value smaller than 50%. The median of the fraction of retweeted tweets calculated over all HPC projects is $\sim 25\%$.

The results on the percentage of retweeted posts are integrated by the average number of times such tweets were retweeted

[1]Hereafter it must be borne in mind that the Twitter profiles used by the DEEP-EST and Mont-Blanc 3 projects have been created for the previous stages of these initiatives: @DEEPprojects was also used for the DEEP and DEEP-ER projects, @MontBlanc_Eu for Mont-Blanc and Mont-Blanc 2, see [63, 65]. Hence, the statistics relative to DEEP-EST and Mont-Blanc 3 have been calculated over the whole activity of the respective accounts.

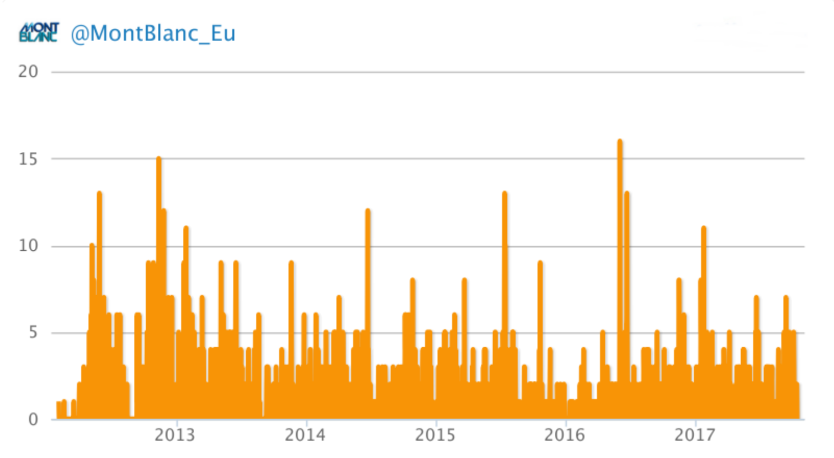


(a)

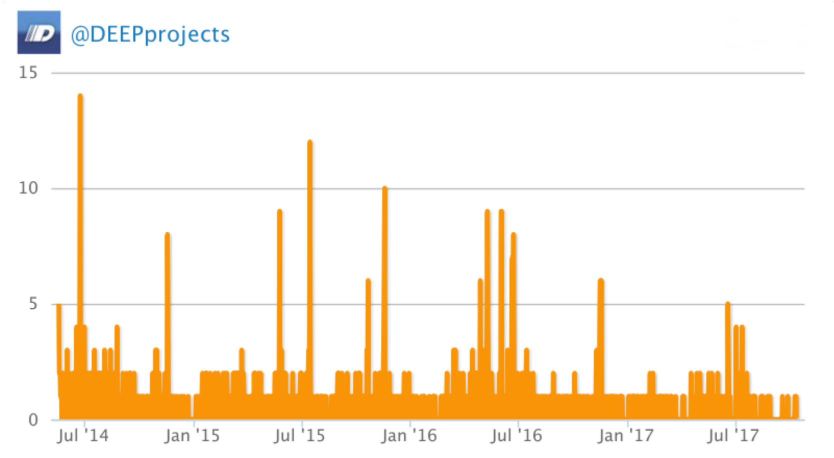


(b)

Figure 4.1: (a) Time distribution of the number of tweets posted by ExaNeSt, the HPC project with the largest average number of tweets per day (1.54) as of 14 October 2017. (b) As for (a) but for EXDCI, the HPC project with the second largest average number of tweets per day (1.53). The plots were generated with the Twitter Analytics Tool Twitonomy.



(a)



(b)

Figure 4.2: (a) Time distribution of the number of tweets posted on the profile used by Mont-Blanc 3, the HPC account with the third largest average number of tweets per day (1.21) as of 14 October 2017. (b) As for (a) but for the profile used by DEEP-EST, the HPC account with the fourth largest average number of tweets per day (0.72). The plots were generated with the Twitter Analytics Tool Twitonomy.

by different users. The higher this value, the more the Twitter community finds the profile's tweets worth to be forwarded.

Table 4.1 shows that six projects have an average number of retweet times higher or equal to two, i.e., retweeted posts have been retweeted by typically more than two users. The median calculated over all profiles is ~ 1.7.

Links and hashtags

Links and hashtags enhance the relevance of a tweet. The higher the average number of links per tweet for a given profile, the more likely the account is a source of information to other users. The higher the average number of hashtags per tweet, the higher the chance that the profile's tweets are found in a search.

As shown in table 4.1, six HPC accounts have an average number of links per tweet higher or equal to 0.5, the value corresponding to one link every second tweet. The median calculated over all HPC accounts is ~ 0.3, i.e. roughly one link every third tweet. Three accounts have an average number of hashtags equal or larger than one. The median is 0.25, corresponding to one hashtag every fourth tweet.

Comparison to the FET Twitter profile

Table 4.1 reports the statistics calculated for the Twitter profile @fet_eu of the FET funding programme as well. Data were collected from 7 January 2016. The date was set by the maximum number of most recent tweets returned by Twitter (3200).

The corresponding average number of tweets per day is roughly thirty times larger than the median calculated for HPC projects. This is probably due to the largest resources available to the FET initiative compared to single HPC projects. Nevertheless, the fraction of retweeted tweets is not significantly larger than the median calculated for the HPC profiles ($\sim 30\%$ vs $\sim 25\%$). The same holds for the average number of links per tweet (~ 0.4 vs ~ 0.3). On the contrary, the average number of hashtags is roughly four times larger (~ 0.9 vs 0.25).

Project	Followers	Following	Followers/Following
ALLScale	41	28	1.46
ANTAREX	77	13	5.92
COMPAT	131	160	0.82
DEEP-EST	697	534	1.31
ECOSCALE	42	1	42
EuroLab-4-HPC	24	2	12
ExaFLOW	206	90	2.29
ExaNeSt	211	261	0.81
ExaNoDe	52	54	0.96
EXDCI	405	169	2.40
EXTRA	45	18	2.50
INTERTWINE	106	59	1.80
MANGO	74	46	1.61
Mont-Blanc 3	1 420	687	2.07
NEXTGenIO	162	44	3.86
READEX	116	55	2.11
SAGE	122	86	1.42
FET	6 499	1 612	4.03

Table 4.2: Number of followers and followed accounts (following) on Twitter of the HPC projects as of 14 October 2017. Influential profiles are identified by high numbers of followers and high values of the ratio between followers and following. The last row refers to the @fet_eu profile of the FET funding programme. Data were collected with the Twitter Analytics Tool Twitonomy.

4.2 Most influential projects

There are disparate ways to estimate the influence of Twitter profiles. One is based on both *i*) the number of followers, and *ii*) the ratio between the number of followers and the number of accounts followed by the considered profile (following). Influential users are identified by a large community of followers and a high ratio followers/following.

Table 4.2 lists the number of followers and following for each HPC project, together with the ratio followers/following. Data were collected on 14 October 2017 with the Twitonomy application. The medians of the number of followers and of the values followers/following are equal to 116 and 2.07, respectively.

To identify the most influential profiles among HPC projects,

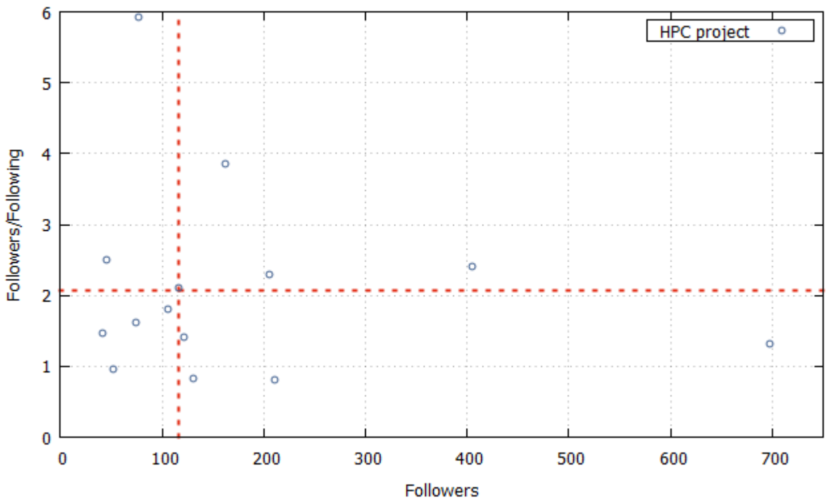


Figure 4.3: Distribution of HPC projects as a function of the number of followers and of the ratio between followers and followed accounts (following) on Twitter. The dashed lines identify the medians of the numbers of followers and of the ratios followers/following calculated over the HPC profiles. The most influential projects are located in the upper right quarter (high number of followers and high values of followers/following). For the sake of clarity, the figure shows the followers and followers/following ranges up to 750 and 6, respectively. The following projects were used to calculated the medians but lie outside the plotted ranges: ECOSCALE (42 followers and follower/following equal to 42), EuroLab-4-HPC (24 and 12) and Mont-Blanc 3 (1420 and 2.07). Data were collected on 14 October 2017 with the Twitter Analytics Tool Twitonomy.

the following analysis was performed. First, projects were distributed on a plane as a function of the number of followers and of the ratio followers/following, see figure 4.3. Second, the plane was divided into four regions by drawing the lines corresponding to the aforementioned medians of the number of followers and of the values followers/following. The most influential HPC

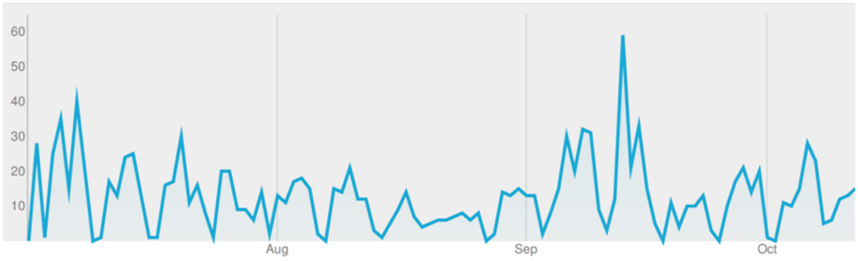


Figure 4.4: Time distribution of the mentions of HPC profiles on Twitter between 1 July and 12 October 2017. The plot was created with the Twitter Analytics Tool NUVI.

projects fall in the quarter of the plane identified by the conditions that the number of followers is larger than 116 and the ratio followers/following is larger than 2.07.

By following this procedure, the most influential projects were found to be ExaFLOW (206, 2.29), EXDCI (405, 2.40), Mont-Blanc 3 (1420, 2.07) and NEXTGenIO (162, 3.86). The READEX profile (116, 2.11) is representative of the influence of HPC projects, as its values lie very close to the calculated medians. For comparison, the @fet_eu profile of the FET funding programme has 6499 followers and a ratio followers/following equal to 4.03.

4.3 Mentions of HPC profiles

Another approach to estimate the influence of HPC projects on Twitter consists of monitoring the mentions of their accounts (i.e., mentions of @AllScaleEurope, @antarex_project etc.). The monitoring activity was conducted from 1 July to 12 October 2017 with the Twitter Analytics Tool NUVI [66].

Overview

Monitored mentions sum up to 1323. The time distribution of the mentions is shown in figure 4.4. The conversation peak hap-

Shared word	Mentions	Fraction of total mentions
amp	22	2.2%
project	18	1.8%
supercomputer	16	1.6%
application	15	1.5%
etp4h	14	1.4%
compute	11	1.1%

Table 4.3: List of the most shared words in the 1005 mentions of the HPC profiles which came across 485 of the major categories considered by the Twitter Analytics Tool NUVI. These mentions are a subset of the 1323 mentions monitored with NUVI between 1 July and 12 October 2017. The second and third columns report the amount of mentions in which the considered word was shared and the percentage of the total mentions.

pened on 12 September 2017 (59 mentions). During the peak, the most frequently used keywords were *filippo mantovani*, *workshop*, *server cpu*, *prototype* and *processors*. An overview of the topics discussed in the monitored mentions is provided in figure 4.5. The figure is based on the 1005 mentions which came across 485 major categories over the monitored time. The list of the most shared words is in table 4.3.

Virality of the mentions

Reach and spread together give an estimate of the potential audience which came across with the tweeted content. The reach is calculated as the sum of the followers of the accounts which mentioned the analysed keyword. The spread is defined as the sum of the followers of the accounts which retweeted or shared the posts with the mention. Figure 4.6 shows the mentions with the largest reach and spread, as well as the most popular one.

Out of the 1323 monitored mentions, 637 were original posts. These had the combined potential of reaching an audience of

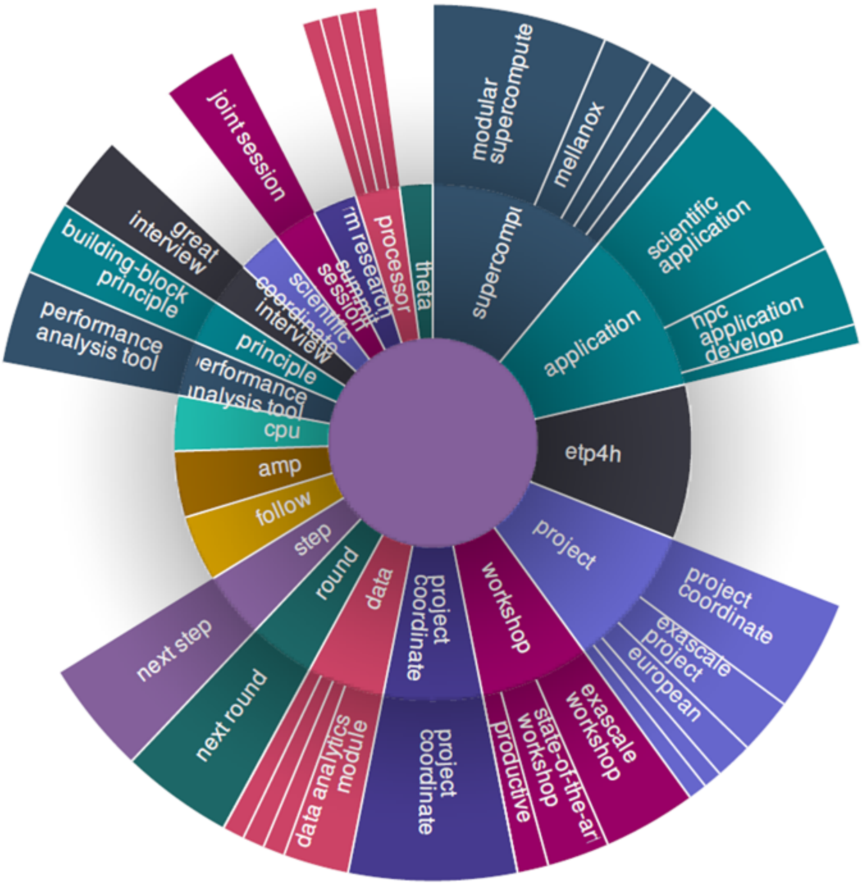


Figure 4.5: Word burst of the mentions of HPC profiles monitored between 1 July and 12 October 2017 on Twitter. The figure is based on the 1005 mentions (out of 1323) which triggered 485 major categories. The analysis was performed with the Twitter Analytics Tool NUVI.

172720 users. A total amount of 686 reshares was made by 116 unique profiles. The reshares spread the mentions to 233974 users.

The ratio between spread and reach defines the viral coefficient. This is equal to 1.4 for the monitored mentions and over

Figure 4.6: Three of the 1323 mentions of HPC projects on Twitter monitored between 1 July and 12 October 2017. The posts are the mentions with the most reach, the most spread and the most popular one. Data were collected with the Twitter Analytics Tool NUVI.

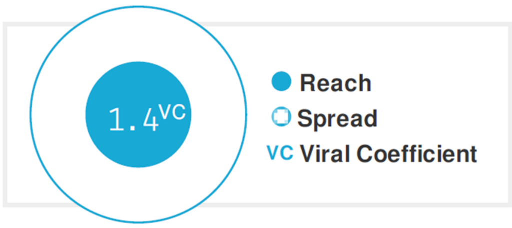


Figure 4.7: Pictorial comparison of the reach (172720 users) and spread (233974 users) of the mentions of HPC projects on Twitter between 1 July and 12 October 2017. The viral coefficient is defined as the ratio between spread and reach. Data were collected with the Twitter Analytics Tool NUVI.

the considered period, see figure 4.7. As the viral coefficient is larger than one, monitored mentions can be considered extremely viral.

Project	Reach	Spread	Viral coefficient
ALLScale	48	0	0.0
ANTAREX	202	9	0.0
COMPAT	13 286	112	0.0
DEEP-EST	11 759	6 988	0.6
ECOSCALE	55	2 268	41.2
EuroLab-4-HPC	2 135	14 679	6.9
ExaFLOW	18 366	28 311	1.5
ExaNeSt	18 109	62 259	3.4
ExaNoDe	6 559	4 470	0.7
EXDCI	111 534	23 082	0.2
EXTRA	216	24	0.1
INTERTWINE	7 436	6 673	0.9
MANGO	1 360	162	0.1
Mont-Blanc 3	30 362	58 782	1.9
NEXTGenIO	4 056	53 838	13.5
READEX	117	0	0.0
SAGE	1 537	4 836	3.1

Table 4.4: Reach, spread and viral coefficient of the mentions of each HPC project on Twitter between 1 July and 12 October 2017. The viral coefficient is defined as the ratio between spread and reach. Data were collected with the Twitter Analytics Tool NUVI.

4.4 Projects with most viral mentions

Results in section 4.3 refer to the whole set of mentions of HPC projects monitored over the considered weeks. The data breakdown for each single project is reported in table 4.4. It is worth noting that the values of reach, spread and viral coefficient vary significantly among HPC projects. The medians of the three variables are 4056, 4836 and 0.7, respectively.

Seven out of seventeen projects have been mentioned in viral conversations (i.e., with viral coefficient larger than one). The projects with the largest viral coefficients are ECOSCALE (41.2), NEXTGenIO (13.5) and EuroLab-4-HPC (6.9). It is worth noting the following: *i*) the large viral coefficient of ECOSCALE originates from the project's low reach; *ii*) EuroLab-4-HPC is mentioned in viral posts although it had posted no tweets by the time of writing, see table 4.1; *iii*) with the exception of EXDCI, the most influential projects identified in section 4.2 are all mentioned in viral conversations.

4.5 Chapter summary

In this chapter, the following items have been discussed:

1. The activity of HPC projects on Twitter varies from roughly one tweet every three months and three tweets every second day. The median calculated over all HPC Twitter profiles is approximately one tweet per week. HPC projects perform well in terms of profile's tweets retweeted by other users and shared links. The medians of the two statistics are comparable to the corresponding values calculated for the Twitter account of the FET funding programme.

2. The most influential HPC projects on Twitter were found to be ExaFLOW, EXDCI, Mont-Blanc 3 and NEXTGenIO. In general, HPC influential initiatives are identified by a number of followers and a ratio followers/following larger than ~ 100 and ~ 2, respectively.

3. The mentions of HPC projects on Twitter were found to be viral over a period of three and a half months. The result indicates that the Twitter community interested in FET HPC initiatives is large. This supports the decision of the vast majority of HPC projects to consider Twitter for their communication campaigns.

4. In general, the most influential HPC projects are also those mentioned in the most viral monitored conversations.

Chapter 5

The Twitter potential reach of FET projects on quantum technologies

As shown in chapter 3, FET research projects on QT make limited use of online communication channels. In particular, none of them has considered the creation of an account on Twitter, the most common social platform among FET initiatives. It is therefore interesting to assess the broadness of the community which could be reached by QT projects via Twitter.

To this aim, the following analysis was performed. First, one hashtag likely to be mentioned in QT-related tweets was chosen. The hashtag was then monitored over two periods of time. The same procedure was repeated for one hashtag representative of mentions on HPC. The comparison of the outcomes of the two monitoring procedures provided an estimate of the communication potential of FET QT projects via Twitter. The monitoring activities were performed with the Twitter Analytics Tool Twitonomy. The Twitonomy application was also used to obtain all figures in this chapter.

HPC was chosen as a suitable class for comparison for the following reasons: *i*) HPC and QTs are among the most important topics in FET communication, see figure 5.1; *ii*) HPC projects are

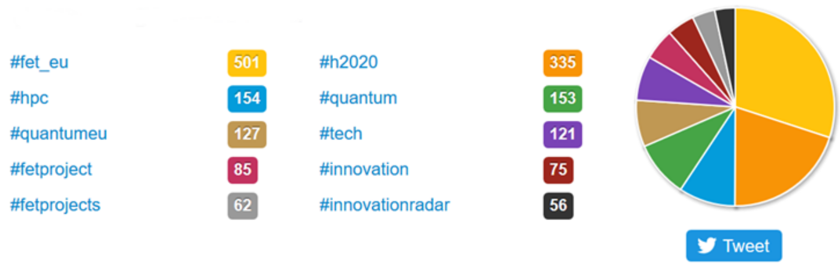


Figure 5.1: Most used hashtags of the Twitter profile @fet_eu of the FET funding programme. The values refer to the 3 199 tweets posted by the account between 8 January 2016 and 25 October 2017. HPC- and QT-related hashtags are the first in the ranking among scientific keywords.

active initiatives within the FET community in terms of online communication; *iii*) HPC and QT projects share similar communication challenges, see section 3.5.

This chapter is structured as follows. Sections 5.1 and 5.2 outline the monitoring activity launched for the QT and HPC hashtags. The comparison of the results and the assessment of the Twitter potential community of FET QT projects are reported in section 5.3.

5.1 Monitoring of the QT hashtag

The QT hashtag monitored for the analysis presented in this chapter was #quantumcomputing. The hashtag was chosen for the relevance of quantum computers in QT research, see section 2.4.

The monitoring activity covered two periods of time: from 7 to 14 and from 20 to 25 October 2017, respectively. The time periods were chosen randomly and based on the amount of mentions which could be tracked by Twitonomy. Different choices of

Time period	Tweets	Users	Reach
7 - 14 Oct 2017	1 928	1 270	9 392 166
20 - 25 Oct 2017	2 563	1 738	10 604 445

Table 5.1: Statistics calculated for the mentions on Twitter of the hashtag #quantumcomputing over the monitored time periods. The reach is defined as the total aggregate number of followers of the accounts which mentioned the considered keyword in their tweets.

the time periods would not change the order of magnitude of the estimates presented in this chapter.

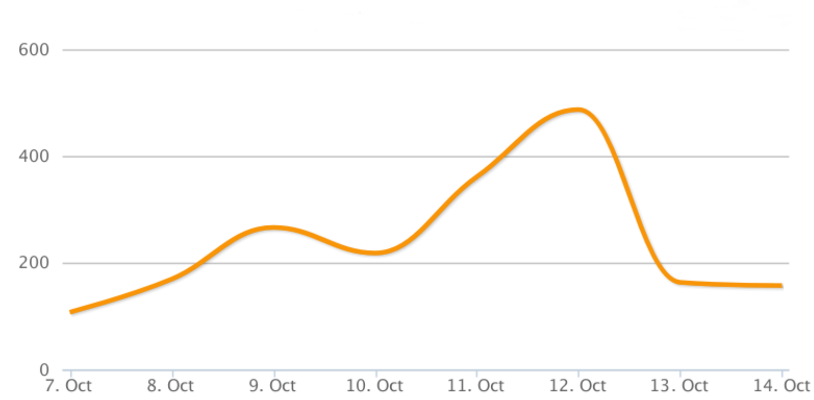
The distribution of the number of tweets mentioning the hashtag #quantumcomputing over the considered time periods is shown in figure 5.2. The plots indicate that, typically, #quantumcomputing is mentioned in hundreds of tweets each day. The reach offered by #quantumcomputing is available in table 5.1. This is calculated as the sum of the followers of the profiles which posted tweets mentioning the considered keyword. The table shows that #quantumcomputing reaches a potential community of the order of ten million users in roughly a week.

5.2 Monitoring of the HPC hashtag

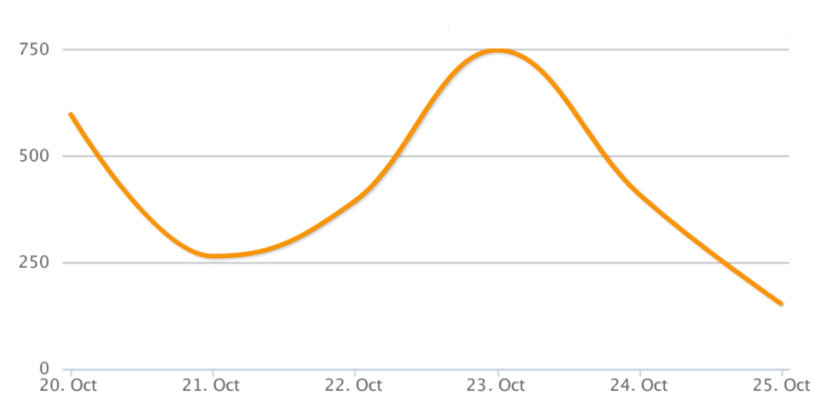
An analysis similar to the one outlined in section 5.1 was conducted for the HPC case. The considered keyword was #hpc. This hashtag was chosen as it identifies mentions to the general thematic area.

The monitored time periods ranged from 4 to 14 and from 15 to 25 October 2017. The time distributions of the tweets mentioning #hpc are shown in figure 5.3. The plots indicate that #hpc is mentioned in hundreds of tweets per day.

An overview of the potential reach achievable with #hpc is available in table 5.2. Similarly to #quantumcomputing, the

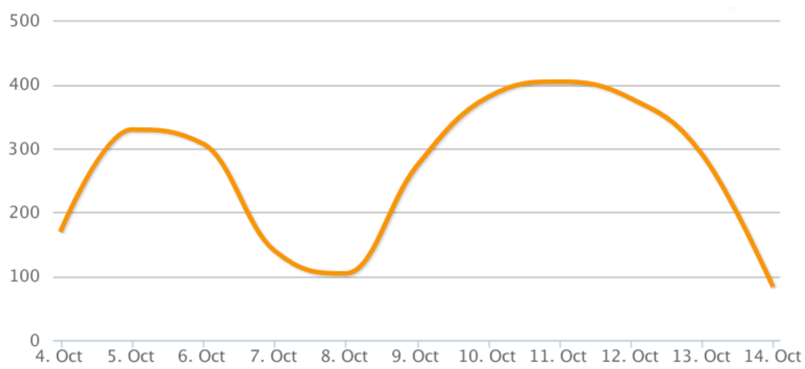


(a)

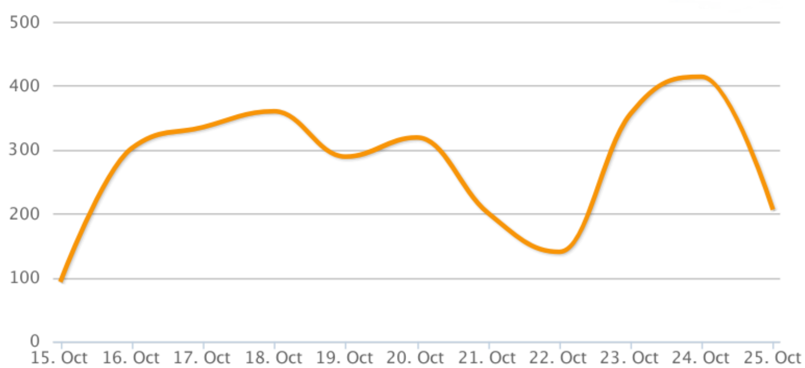


(b)

Figure 5.2: (a) Time distribution of the number of tweets with hashtag #quantumcomputing posted between 7 and 14 October 2017. (b) As for (a) but over the time period between 20 and 25 October 2017.



(a)



(b)

Figure 5.3: (a) Time distribution of the number of tweets with hashtag #hpc posted between 4 and 14 October 2017. (b) As for (a) but over the time period between 15 and 25 October 2017.

Time period	Tweets	Users	Reach
4 - 14 Oct 2017	2 857	1 372	11 533 160
20 - 25 Oct 2017	3 015	1 475	13 315 746

Table 5.2: Statistics calculated for the mentions on Twitter of the hashtag #hpc over the monitored time periods. The reach is defined as the total aggregate number of followers of the accounts which mentioned the considered keyword in their tweets.

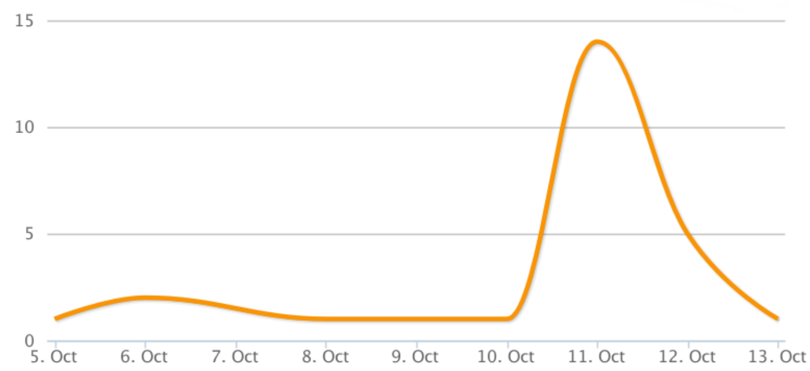
reach of #hpc is of the order of ten million of users over roughly a week.

5.3 Comparison of the results

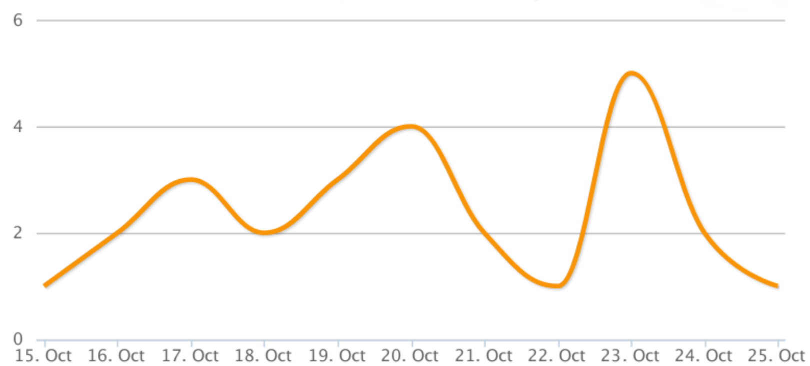
The monitoring activities outlined in sections 5.1 and 5.2 suggest the following:

- Tweets on QTs have a potential reach of millions of people via Twitter. Thus, it may be worth for FET QT projects to consider Twitter as a suitable channel for communication and dissemination activities.
- The potential reaches of tweets mentioning #quantumcomputing and #hpc share the same order of magnitude. The same holds for the total amount of tweets and users. Hence, QT projects may achieve results similar to those reported in chapter 4 for the case of HPC initiatives.

It is worth noting that the number of tracked posts mentioning both hashtags is very low, see figure 5.4. The plots show that the amount of tweets is one order of magnitude smaller than those in figures 5.2 and 5.3. The result is probably due to the fact that QTs and HPC pursue different strategies to improve current computers, see section 3.5. As a consequence, QT projects may generate an amount of conversations on FET-funded research comparable to that provided by HPC initiatives.



(a)



(b)

Figure 5.4: (a) Time distribution of the number of tweets with both hashtags #hpc and #quantumcomputing posted between 5 and 13 October 2017. (b) As for (a) but over the time period between 15 and 25 October 2017.

5.4 Chapter summary

In this chapter, the following items have been discussed:

1. FET QT projects are not active on Twitter. Nevertheless, an estimate of their potential reach indicates a community of millions of profiles. This suggests that it may be worth for QT projects to consider Twitter for developing effective communication and dissemination strategies.

2. The potential reach of QT and HPC projects on Twitter were assessed to be comparable. Moreover, conversations on both topics are very rare. Hence, the development of communication campaigns making use of Twitter may enable QT projects to increase the spread of FET-funded research by the same factor as HPC initiatives.

Conclusions

This thesis focused on the online aspects of the communication campaigns designed by FET research projects. The results indicate that FET initiatives do consider social media as an opportunity to reach stakeholders and the general public. Nevertheless, the use of online channels is not uniform across disparate FET investigation lines.

One example is offered by HPC and QT research projects. The two classes face similar communication challenges and pursue partially overlapping objectives (although the strategies to achieve them are very different). Despite such similarities, the approaches followed by HPC and QT projects are opposite. On one hand, HPC initiatives make an effective use of popular social media such as Twitter and Facebook. On the other hand, QT projects do not base their communication efforts on online platforms. In particular, they disregard Twitter.

The motivation for the different behaviour lies probably in the fact that the development of QTs is still in the initial phase. It is not known yet whether this effort will indeed be successful. Hence, applications to society are not to be expected in the near future.

Nevertheless, the limited use of social media made by QT projects may reduce the societal uptake of this investigation line. The potential reach of QT initiatives was estimated to be comparable to the online community interested in HPC projects, which consists of hundreds of thousands of users. Expanding the community coming in contact with QT research would draw attention on this potentially groundbreaking scientific frontier and may attract investors.

A more active use of social media may be expected from the FET Flagship initiative on QTs. This is one of the major investigation efforts ever undertaken by the European Union and will be launched in 2018. However, a strong presence of QT projects on social platforms prior to the beginning of the flagship initiative may have *i*) provided useful hints and guidelines on how to best design an effective QT communication strategy, and *ii*) contributed to building a preexisting engaged community.

Appendix A

List of FET projects

This appendix lists all FET projects funded within the Horizon 2020 programme as of 15 July 2017. The list was downloaded from the CORDIS portal [62] and is available in table A.1. For each project, table A.1 shows also the start and end date, the total budget and the EU budget contribution.

This appendix reports also the projects' accounts activated on the communication channels considered for the thesis. The links to the websites and Twitter and Facebook profiles are available in table A.1. The lists of the accounts activated on LinkedIn, YouTube, Instagram and ResearchGate are reported in table A.2, A.3, A.4 and A.5, respectively.

The search performed to find the channels activated by the projects is described in section 3.3. As discussed in that section, the search may have failed to find all accounts created on the considered channels. Hence, the tables in this appendix may be incomplete.

Project	Start date	End date	Total fund	EU fund	Website	Twitter	Facebook
ABIOMATER	01/11/2015	31/10/2018	2 978 882	2 978 882	blogs.exeter.ac.uk/abiomater	@abiomater	
A-LEAF	01/01/2017	31/12/2020	7 980 861	7 980 861	a-leaf.eu	@aleaf_h2020	aleaf.h2020
ALLScale	01/10/2015	30/09/2018	3 366 196	3 366 196	allscale.eu/home	@AllScaleEurope	AllScaleProject
AMECRYS	01/10/2016	30/09/2020	3 533 813	3 533 813	amecrys-project.eu	@amecrysproject	amecrysproject
AMADEUS	01/01/2017	31/12/2019	3 270 496	3 270 496	amadeus-project.eu		
ANTAREX	01/09/2015	31/08/2018	3 115 251	3 115 251	antarex-project.eu	@antarex_project	
aPad	01/05/2017	31/10/2018	99 750	99 750			
AQuS	01/01/2015	31/12/2017	2 000 500	2 000 500	kip.uni-heidelberg.de/aqus		
ArrestAD	01/01/2017	31/12/2020	3 991 096	3 991 096	arrestad.wordpress.com	@H2020_ArrestAD	
Bio4Comp	01/01/2017	31/12/2021	6 084 949	6 084 949	bio4comp.org		
BrainCom	01/12/2016	30/11/2021	8 648 827	8 648 827	braincom-project.eu		
BrainHack	01/01/2016	31/12/2017	549 727	549 727	hackthebrain-hub.com	@HackTheBrainHub	
BREAKBEN	01/01/2016	31/12/2018	3 998 793	3 998 793	breakben.eu	@BREAKBENeu	
ByAxon	01/01/2017	31/12/2020	3 752 057	3 752 057	byaxon-project.eu	@ByAxon_Project	ByAxon
CARBOMET	01/01/2017	31/12/2020	496 607	496 607	carbomet.eu	@CarboMet_EU	
CASEK	01/04/2017	30/09/2018	100 000	100 000	casek.eu		
CATCH-U-DNA	01/06/2017	31/05/2020	3 412 478	3 411 478			
CellViewer	01/02/2016	31/01/2020	3 988 752	3 988 752	cellviewer.eu	@CellViewer_EU	
CF-Web	01/06/2017	30/11/2018	99 125	99 125			
ChipScope	01/01/2017	31/12/2020	3 759 790	3 759 790	chipscope.eu	@ChipScope_EU	chipscope
CHROMAVISION	01/06/2015	31/05/2019	3 567 025	3 567 025	chromavision.eu		
CIMPLEX	01/01/2015	31/12/2017	4 206 875	3 450 625	cimplex-project.eu	@CimplexProject	
CIRCLE	01/06/2015	31/05/2017	532 336	532 336	fet-circle.eu	@fetcircle	
ComPat	01/10/2015	30/09/2018	4 122 864	3 942 885	compat-project.eu	@compatproject	
CompInnova	01/09/2015	28/02/2019	2 495 863	2 495 863	compinnova.eu		
CONQUER	01/09/2015	31/08/2018	2 463 975	2 463 975	conquer.at		
CResPace	01/01/2017	31/12/2021	4 944 347	4 944 347	crespace.eu		
DEDALE	01/10/2015	30/09/2018	2 702 397	2 702 397	dedale.cosmostat.org	@dedale_fet	DEDALE.FET
DEEP-EST	01/07/2017	30/06/2020	15 873 341	14 998 342	deep-projects.eu	@DEEPprojects	
DIACAT	01/07/2015	30/06/2019	3 872 981	3 872 981	diacat.eu	@DIACAT_EU	
DISCOVERER	01/01/2017	31/03/2021	5 726 750	5 726 750	discoverer.space	@DISCOVERER_EU	
DMS	01/04/2017	30/09/2018	100 000	100 000			
D-Noise	01/05/2017	31/10/2018	130 937	100 000	d-noise-fet.eu		
DOLFINS	01/03/2015	28/02/2018	4 250 000	3 270 646	simpolproject.eu	@SimPolProject	
DREAM	01/01/2015	31/12/2018	2 784 240	2 730 241	robotsthatdream.eu	@robotsthatdream	
ECOSCALE	01/10/2015	30/09/2018	4 237 397	4 237 397	ecoscale.eu	@ECOSCALE_H2020	
EFFECT	01/01/2017	31/12/2018	499 937	499 937	fetfx.eu	@FETFX_EU	
ENTIMENT	01/07/2017	31/12/2018	100 000	100 000			
EuroEXA	01/09/2017	28/02/2021	19 949 022	19 949 022			
ESCAPE	01/10/2015	30/09/2018	3 977 952	3 977 952	hpc-escape.eu		
EuroLab-4-HPC	01/09/2015	31/08/2017	1 489 981	1 489 981	eurolab4hpc.eu	@eurolab4hpc	
ExaFLOW	01/10/2015	30/09/2018	3 312 235	3 312 235	exaflow-project.eu	@exaflowproject	
ExaHyPE	01/10/2015	30/09/2019	2 872 500	2 795 000	exahype.eu		
ExaNeSt	01/12/2015	30/11/2018	8 442 547	8 442 547	exanest.eu	@exanest_h2020	Exanest_h2020-282450078883797
ExaNoDe	01/10/2015	30/09/2018	8 629 247	8 629 247	exanode.eu	@ExanodeProject	Exanode-1669383456699997
ExCAPE	01/09/2015	31/08/2018	3 910 140	3 910 140	excape-h2020.eu		
EXDCI	01/09/2015	28/02/2018	2 551 875	2 551 875	exdci.eu	@exdci_eu	
EXTRA	01/09/2015	31/08/2018	3 989 931	3 989 931	extrahpc.eu	@extrahpc	groups/extrahpc
FEAT	01/11/2015	31/10/2017	492 937	492 312	featart.eu	@FEATART	groups/361202720889978
FEMTOTERABYTE	01/03/2017	29/02/2020	3 712 832	3 712 832	physics.gu.se/english/research/femtoterabyte		

Project	Start date	End date	Total fund	EU fund	Website	Twitter	Facebook
FET_TRACES	15/07/2015	14/11/2017	383 593	383 593	fet-traces.eu/traces		
FET-Event	01/09/2015	30/11/2016	998 750	998 750			
FET2RIN	01/12/2015	30/11/2018	472 468	472 468	fet2rin.com	@Fet2Rin	fet2rin
FLAG-ERA II	01/12/2016	30/11/2021	18 341 250	6 052 612	flagera.eu		flagera
FLIPT	01/09/2016	31/08/2019	3 741 871	3 741 871	flipt.group.shef.ac.uk	@H2020FLIPT	
flora robotica	01/04/2015	31/03/2019	3 641 781	3 641 781	florarobotica.eu	@florarobotica	florarobotica
FutureAgriculture	01/01/2016	31/12/2020	4 871 410	4 871 410	futureagriculture.eu	@FutureAgric	FutureAgriculture-1726501137660793
GOAL-Robots	01/11/2016	31/10/2020	3 481 875	3 481 875	goal-robots.eu		
GOTSolar	01/01/2016	31/12/2018	2 993 403	2 993 403	gotsolar.eu		
GRACeFUL	01/02/2015	31/01/2018	2 404 943	2 404 943	graceful-project.eu	@gracefulproject	
GrapheneCore1	01/04/2016	31/03/2018	89 000 000	89 000 000	graphene-flagship.eu	@GrapheneCA	GrapheneFlagship
greenFLASH	01/10/2015	30/09/2018	3 760 793	3 760 793	greenflash-h2020.eu		
HBP SGA1	01/04/2016	31/03/2018	89 000 000	89 000 000	humanbrainproject.eu/en/	@HumanBrainProj	humanbrainproj
HELENIC-REF	01/06/2015	31/05/2018	2 578 386	2 578 386	helenic-ref.eu		
HISTO-MRI	01/01/2017	31/12/2019	3 216 250	3 216 250			
HOT	01/01/2017	31/12/2020	10 000 000	10 000 000			
IBSEN	01/09/2015	31/08/2018	2 663 237	2 663 237	ibsen-h2020.eu	@IBSEN_H2020	ibsenh2020
ICARUS	01/09/2016	31/08/2019	2 698 062	2 698 062	icarus-alloys.eu	@ICARUS_ALLOYS	
InnoSMART	01/07/2015	30/06/2018	1 995 113	1 995 113	inno-smart.eu		
INTERLACE	01/05/2017	31/10/2018	99 978	99 978			
INTERTWINE	01/10/2015	30/09/2018	3 861 400	3 861 400	intertwine-project.eu	@intertwine_eu	
I2C8	01/05/2017	30/04/2018	99 937	99 937	lrn2cre8.eu		
Levitate	01/01/2017	31/12/2020	2 999 870	2 999 870	levitateproject.org	@LevitateProj	
LIAR	01/04/2016	31/03/2019	3 216 555	3 216 555	livingarchitecture-h2020.eu		
LiNaBioFluid	01/07/2015	30/06/2018	3 024 827	3 024 827	laserbiofluid.eu		
LiRichFCC	01/10/2016	30/09/2019	4 114 753	4 114 753	lirichfcc.eu		
LLR	01/01/2017	31/12/2020	3 962 500	3 956 500	llr-fet.eu		
LMCat	01/01/2017	31/12/2020	3 726 942	3 726 942	lmcat.eu		
Lumiblast	01/10/2016	31/03/2021	3 031 375	3 031 375	lumiblast.eu		
LUMINOUS	01/03/2016	31/08/2019	3 925 588	3 925 588	luminous-project.eu	@LuminousEU	
MAGENTA	01/01/2017	31/12/2020	4 999 778	4 999 777	magenta-h2020.eu		
MAGicSky	01/09/2015	31/08/2018	3 396 439	3 396 439	magicsky-fet.eu	@magicskyf	
MagnaPharm	01/01/2017	31/12/2019	2 886 323	2 886 323	magnapharm.com	@MagnaPharm	
MAGNEURON	01/01/2016	31/12/2019	3 473 026	3 473 026	magneuron.eu		
MANGO	01/10/2015	30/09/2018	5 801 820	5 801 820	mango-project.eu	@mangoeu	
MaQSens	01/01/2017	31/12/2019	3 082 755	2 699 369	maqsens.univie.ac.at		
MARA	01/12/2015	30/11/2019	3 996 477	3 996 477	maraproject.eu		
M-CUBE	01/01/2017	31/12/2020	4 582 346	3 945 346	mcube-project.eu	@MCUBE19	h2020fetopen
MECHANO-CONTROL	01/01/2017	31/12/2021	7 134 928	7 134 928	mechanocontrol.eu	@Mechanocontrol	
MESO_BRAIN	01/09/2016	31/08/2019	3 225 890	3 225 890	mesobrain.eu	@MesoBrain	MesoBrain
Microflusa	01/09/2015	31/08/2019	3 027 637	3 027 637	microflusa-project.eu		
MIR-BOSE	01/01/2017	31/12/2020	3 786 160	3 786 160	mir-bose.eu		
Mont-Blanc 3	01/10/2015	30/09/2018	7 968 375	7 968 375	montblanc-project.eu/montblanc-3	@MontBlanc_Eu	MontBlancEU
MRG-GRammar	01/08/2015	31/07/2018	3 999 661	3 999 661	mrg-grammar.eu	@MrgGrammar_proj	mrggrammar
NANOARCHITECTRONICS	01/01/2017	31/12/2018	670 000	670 000	nanoarchitectronics.eu		
NanOQTech	01/10/2016	30/09/2019	3 378 428	3 378 428	nanoqtech.eu		
NanoSmell	01/09/2015	31/08/2019	3 979 069	3 979 069	nanosmell.org		
NEMF21	01/10/2015	30/09/2018	3 419 637	3 419 637	nemf21.org		
NEURAM	01/10/2016	30/09/2019	4 271 481	4 271 481	neuram.eu	@neuronal_func	groups/neuram
Neurofibres	01/01/2017	31/12/2020	5 888 491	5 094 120	neurofibres.eu	@neurofibres	

Project	Start date	End date	Total fund	EU fund	Website	Twitter	Facebook
NEXTGenIO	01/10/2015	30/09/2018	8 114 504	8 114 504	nextgenio.eu	@nextgenio	
NLAFET	01/11/2015	31/10/2018	3 907 375	3 907 375	nlafet.eu		
nuClock	01/06/2015	31/05/2019	3 970 327	3 970 327	nuclock.eu		nuclock.eu
OBSERVE	01/06/2015	31/05/2017	410 093	410 093	horizon-observatory.eu/ radar-en/index.php		
ODYCCEUS	01/01/2017	31/12/2020	5 817 276	5 817 276	odycceus.eu	@Odycceus_EU	odycceus
One-Flow	01/01/2017	31/12/2020	3 896 827	3 896 827	one-flow.org		
OPRECOMP	01/01/2017	31/12/2020	5 990 510	5 990 510	oprecomp.eu	@oprecompproject	
PHASE-CHANGE SWITCH	01/01/2017	30/06/2020	3 883 412	3 883 412			
PHENOMEN	01/09/2016	31/08/2019	2 915 886	2 915 886	phenomen-project.eu		
Phoenix	01/10/2015	30/09/2019	3 632 486	3 632 486	phoenix-project.eu	@Phoenix_FET	
PhySense	01/06/2017	31/05/2018	99 991	99 991	physense.eu		
Plan4Act	01/01/2017	31/12/2020	4 236 000	4 236 000	plan4act-project.eu		
PROSEQO	01/03/2016	28/02/2019	2 906 801	2 906 801	singleproteinsequencing.eu	@OProseq	
QCUMbER	01/09/2015	31/08/2018	3 219 721	3 219 721	qcumber.eu		
Qdet	01/05/2017	31/10/2018	100 000	100 000			
QuantERA	01/11/2016	31/10/2021	40 464 570	11 510 008	quantera.eu		QuanteraCoFund
QUCHIP	01/03/2015	28/02/2018	2 681 713	2 681 713	quchip.eu		
QUIC	01/03/2015	28/02/2019	2 774 375	2 386 875	quic-project.eu		
QuProCS	01/04/2015	31/03/2018	2 268 746	2 268 746	quprocs.eu		
QUSMI	01/05/2017	31/10/2018	96 462	96 462	nvision-imaging.com		
READEX	01/09/2015	31/08/2018	3 534 198	3 534 198	readex.eu	@readex_eu	
RECORD-IT	01/09/2015	31/08/2018	4 193 147	4 193 147	chalmers.se/en/projects/ Pages/RECORD-IT.aspx		
ROMA	01/06/2017	30/11/2018	99 675	99 675			
RYSQ	01/03/2015	28/02/2018	4 695 000	4 383 000	qurope.eu/projects/rysq		
SAGE	01/09/2015	31/08/2018	7 882 531	7 882 531	sagestorage.eu	@SageStorage	
SCOPE	01/01/2017	31/12/2019	999 998	999 998	humanbrainproject.eu/ en/open-ethical-engaged/ partnering-projects/scope-project/		SCOPE-project-1939547746300370/
SC-square	01/07/2016	31/08/2018	499 603	499 603	sc-square.org		
SENSE	01/09/2016	31/08/2019	886 500	886 500	sense-pro.org	@senselowlight	
SensAgain	01/09/2017	28/02/2019	99 912	99 912			
SiLAS	01/01/2017	31/12/2020	3 985 417	3 985 417	silasproject.eu		
SmartNurse	01/05/2017	31/10/2018	100 000	100 000			
socSMCs	01/01/2015	31/12/2018	3 778 125	3 778 125	socsmcs.eu	@socSMCs	
SPICE	01/10/2016	30/09/2020	3 395 178	3 395 178	spice-fetopen.eu	@FETOPENSPICE	fetopen.spice.1
subCULTron	01/04/2015	31/03/2019	3 987 650	3 987 650	subcultron.eu	@subCULTron	
SUMCASTEC	01/01/2017	30/06/2020	3 978 517	3 978 517	sumcastec.eu		
SUPERTWIN	01/03/2016	28/02/2019	3 939 516	3 925 921	supertwin.eu	@SUPERTWIN_H2020	
Symbiotic	01/06/2015	31/05/2018	3 346 660	3 346 660	symbiotic-project.eu		
TAIPI	01/01/2015	31/12/2017	873 442	799 837	taipi.eu		
TIMESTORM	01/01/2015	30/06/2018	2 892 500	2 892 500	timestorm.eu		
TISuMR	01/01/2017	31/12/2020	3 138 432	3 138 432	tisumr.soton.ac.uk	@TISuMR	
TRANSPIRE	01/01/2017	31/12/2020	4 430 382	4 430 382	transpire.eu		
2D-INK	01/01/2016	31/12/2018	2 962 661	2 962 661	2d-ink.eu	@2D_INK	2D-INK-1419976004971237
ULTRACHIRAL	01/01/2017	31/12/2020	3 999 250	3 999 250	ultrachiral.iesl.forth.gr	@ultrachiral	
ULTRAQCL	01/10/2015	30/09/2018	2 798 445	2 798 445	ultraqcl.eu		
VIRUSCAN	01/11/2016	31/10/2021	7 148 586	7 148 586			

Project	Start date	End date	Total fund	EU fund	Website	Twitter	Facebook
VISORSURF	01/01/2017	30/06/2020	5 748 000	5 748 000	visorsurf.eu	@VisorSurf	VisorSurf/?ref=br_rs
VOXEL	01/06/2015	31/05/2019	3 996 875	3 996 875	ipfn.tecnico.ulisboa.pt/voxel		
WASPSNEST	01/06/2017	31/05/2018	99 775	99 775	fp7wasps.org/en/		
WhiteRabbit	01/04/2017	31/07/2018	99 750	99 750			
Zoterac	01/09/2015	31/08/2019	3 795 877	3 795 876	zoterac.eu	@Zoterac_Project	

Table A.1: FET projects launched within the Horizon 2020 funding programme as of 15 July 2017. Total and EU funds are expressed in Euro. The links to the websites and Twitter and Facebook accounts were searched for by the author. The search may have missed some of the existing channels, see section 3.3. Thus, the information in the table could be incomplete.

Project	LinkedIn Group
A-LEAF	groups/8599537/profile
ALLScale	in/allscale-new-dimension-in-exascale-computing-621772138/
ByAxon	groups/12049105/profile
CARBOMET	groups/13512994/profile
CIRCLE	company-beta/10862743/
ComPat	groups/8588860/profile
CompInnova	groups/8556682/profile
DEEP-EST	groups/6534965/profileThree
DISCOVERER	groups/13525547/profile
FEAT	groups/4984351
GrapheneCore1	company/graphene-flagship
HELENIC-REF	groups/8556565/profile
ICARUS	groups/13523454/profile
MANGO	groups/7025620/profile
MESO_BRAIN	company/meso-brain
Mont-Blanc 3	groups/5052758/profile
NanOQTech	groups/8590350/profile
QuantERA	groups/12021922/profile
QUSMI	company-beta/10914981/
SCOPE	in/scope-project-b91172150/
SPICE	in/spice-fetopen-944236151/
2D-INK	in/2d-ink-fet-open-a3b927113?trk=pub-pbmap
ULTRACHIRAL	in/ultrachiral

Table A.2: LinkedIn accounts activated by the FET projects funded within the Horizon 2020 programme as of 15 July 2017. The accounts were searched for by the author. The search may have missed some of the existing profiles, see section 3.3. Thus, the information in the table could be incomplete.

Project	YouTube channel
DREAM	channel/UCeZwuAh4u-26gGFMAxZmXfA
EFFECT	channel/UC3ARjRJE8A02w-YA3jEJV9g
ExaHyPE	channel/UCKRM7I8tB6MxidxCuvn3FCA
FLIPT	playlist?list=PLvEe-xlrJTcdDaYpf5pTiepULe2Zy6Nk7
flora robotica	channel/UCkQPj4HB-1IxZJ9AXB-cVxA
FutureAgriculture	channel/UC044LPax5HVSeZrv5jOA6zw
GrapheneCore1	user/GrapheneFlagship?sub_confirmation=1
HBP SGA1	user/TheHumanBrainProject
MANGO	channel/UC8TGUP3T4hgpjHCf4afJFKQ
M-CUBE	channel/UCbauUyFGSFcVRRk6MfBBajA
READEX	channel/UC3GqdiCtlNDyIQkEeiDwYMg

Table A.3: YouTube channels activated by the FET projects funded within the Horizon 2020 programme as of 15 July 2017. The channels were searched for by the author. The search may have missed some of the existing channels, see section 3.3. Thus, the information in the table could be incomplete.

Project	Instagram account
ExaNeSt	exanest_h2020
flora robotica	florarobotica
GrapheneCore1	grapheneflagship
SCOPE	scope_project

Table A.4: Instagram accounts activated by the FET projects funded within the Horizon 2020 programme as of 15 July 2017. The accounts were searched for by the author. The search may have missed some of the existing profiles, see section 3.3. Thus, the information in the table could be incomplete.

Project	ResearchGate account
AMADEUS	AMADEUS-Next-GenerAtion-MateriAls-and-Solid-State-DevicEs-for-Ultra-High-Temperature-Energy-Storage-and-Conversion
AMECRYS	Revolutionising-Downstream-Processing-of-Monoclonal-Antibodies-by-Continuous-Template-Assisted-Membrane-Crystallization-AMECRYS
FEMTOTERABYTE	FEMTOTERABYTE-Spinoptical-nanoantenna-assisted-magnetic-storage-at-few-nanometers-on-femtosecond-timescale
flora robotica	Flora-Robotica-Societies-of-Symbiotic-Robot-Plant-Bio-Hybrids-as-Social-Architectural-Artifacts-2
MAGENTA	Magnetic-nanoparticle-based-liquid-energy-materials-for-thermoelectric-device-applications
ODYCCEUS	ODYCCEUS-Opinion-Dynamics-and-Cultural-Conflict-in-European-Spaces
READEX	READEX
socSMCs	Socializing-Sensorimotor-Contingencies-socSMCs
subCULTron	subCULTron
2D-INK	2D-INK
VISORSURF	VISORSURF-A-Hardware-Platform-for-Software-driven-Functional-Metasurfaces

Table A.5: ResearchGate accounts activated by the FET projects funded within the Horizon 2020 programme as of 15 July 2017. The accounts were searched for by the author. The search may have missed some of the existing profiles, see section 3.3. Thus, the information in the table could be incomplete.

Appendix B

Specific lists of FET projects

Disparate groups consisting of projects in appendix A were considered in this thesis. The motivations for the identification of the groups are outlined in section 3.1. The projects in each of the groups are listed below.

B.1 Disregarded projects

The following groups of projects were not considered for the analyses in this thesis.

Flagship projects: GrapheneCore1 and HBP SGA1.

Launchpad projects: aPad, CASEK, CF-Web, D-Noise, DMS, ENTIMENT, I2C8, INTERLACE, PhySense, Qdet, QUSMI, ROMA, SensAgain, SmartNurse, WASPSNEST and WhiteRabbit.

Started after 1 February 2017: CATCH-U-DNA, EuroEXA, FEMTOTERABYTE, Qdet and QUSMI. The DEEP-EST project was also launched after 1 February 2017. Nevertheless, it was considered for the analysis as it could make use of the channels activated for the DEEP and DEEP-ER projects, see section 3.1. Note that Qdet and QUSMI are also Launchpad projects.

B.2 Investigated classes

This thesis presents a comparison of the use of online communication channels made by projects active in high-performing computing and in the development of quantum technologies. The projects in the two classes are listed below.

High performing computing

ALLScale, ANTAREX, ComPat, DEEP-EST, ECOSCALE, ESCAPE, EuroLab-4-HPC, ExaFLOW, ExaHyPE, ExaNeSt, ExaNoDe, ExCAPE, EXDCI, EXTRA, greenFLASH, INTERTWINE, MANGO, Mont-Blanc 3, NEXTGenIO, NLAFET, READEX and SAGE. The EuroEXA project was not considered as it was launched after 1 February 2017, see section B.1.

Quantum technologies

AQuS, MaQSens, NanOQTech, QCUMbER, QuantERA, QUCHIP, QUIC, QuProCS, RYSQ and ULTRAQCL. The Qdet and QUSMI projects were not considered as they were launched after 1 February 2017 and are two Launchpad projects, see section B.1.

Bibliography

[1] J. Bocquet-Appel, *Science*, vol. 333, p. 560, 2011.

[2] G. Barker, *The Agricultural Revolution in Prehistory: Why did Foragers become Farmers?* Oxford University Press, 2006.

[3] B. Trinder, *Britain's Industrial Revolution: The Making of Manufacturing People, 1700 - 1870.* Carnegie Publishing Ltd, 2013.

[4] E. Griffin, *A Short History of the British Industrial Revolution.* Palgrave Macmillan, 2010.

[5] G. Böhme and N. Stehr, *The Knowledge Society.* Reidel, 1986.

[6] W. W. Powell and K. Snellman, *Annu. Rev. Sociol.*, vol. 30, p. 199, 2004.

[7] J. V. Pickstone, *Ways of Knowing: A New History of Science, Technology and Medicine.* University Of Chicago Press, 2000.

[8] G. Probst *et al.*, *Knowledge as a Strategic Resource, in Knowing in Firms: Understanding, Managing and Measuring Knowledge.* SAGE Publications Ltd, 1998.

[9] Oecd data on gross domestic investments. [Online]. Available: https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm

[10] Unesco institute for statistics, global investments in r&d. [Online]. Available: http://uis.unesco.org/sites/default/files/documents/fs42-global-investments-in-rd-2017-en.pdf

[11] M. Boroush, *National Science Foundation 16-316*, 2016.

[12] R. Kersley and A. Koutsoukis, *The Global Wealth Report 2016*. Credit Suisse Research Institute, 2016.

[13] M. A. Heller and R. S. Eisenberg, *Science*, vol. 280, p. 698, 1998.

[14] A. Maddison, *The World Economy: A Millennial Perspective*. OECD Publishing, 2006.

[15] A. McKenna, *A Human Right to Participate in the Information Society*. Hampton Pr, 2011.

[16] P. Zagorin, *Francis Bacon*. Princeton University Press, 1998.

[17] M. Gibbons, *Nature*, vol. 402, p. C81, 1999.

[18] J. van Dijck, *Science Communication*, vol. 25, p. 177, 2003.

[19] S. Shapin, *Public Unerstand. Sci.*, vol. 1, p. 27, 1992.

[20] V. Árnason, *Public Understand. Sci.*, vol. 22, p. 927, 2012.

[21] H. Nowotny *et al.*, *Re-Thinking Science: Knowledge and the Public in an Age of Uncertainty*. Cambridge Polity Press, 2001.

[22] P. Galison and B. Hevly, *Big Science: The Growth of Large-Scale Research*. Stanford University Press, 1992.

[23] Cern web page. [Online]. Available: https://home.cern/

[24] Ligo web page. [Online]. Available: http://ligo.org/

[25] Virgo web page. [Online]. Available: http://www.virgo-gw.eu/

[26] R. Holliman *et al.*, *Investigating Science Communication in the Information Age.* Oxford University Press, 2008.

[27] B. Wynne, *Misundertood misunderstanding: social identities and public uptake of science, in Misunderstanding Science? The Public Reconstruction of Science and Technology.* Cambridge University Press, 1996.

[28] J. Burke, *The Day the Universe Changed.* Back Bay Books, 1995.

[29] Horizon 2020. [Online]. Available: https://ec.europa.eu/programmes/horizon2020/en

[30] Fp4 programme. [Online]. Available: http://cordis.europa.eu/fp4/

[31] Fp5 programme. [Online]. Available: http://cordis.europa.eu/fp5/

[32] Fp6 programme. [Online]. Available: https://ec.europa.eu/research/fp6/index_en.cfm

[33] Fp7 programme. [Online]. Available: https://ec.europa.eu/research/fp7/index_en.cfm

[34] Framework programme's budget growth. [Online]. Available: https://ec.europa.eu/research/fp7/index_en.cfm?pg=budget

[35] Factsheet: Horizon 2020 budget. [Online]. Available: https://ec.europa.eu/research/horizon2020/pdf/press/fact_sheet_on_horizon2020_budget.pdf

[36] Excellent science initiative. [Online]. Available: https://ec.europa.eu/programmes/horizon2020/en/h2020-section/excellent-science

[37] Industrial leadership initiative. [Online]. Available: https://ec.europa.eu/programmes/horizon2020/en/h2020-section/industrial-leadership

[38] Societal challenges initiative. [Online]. Available: https://ec.europa.eu/programmes/horizon2020/en/h2020-section/societal-challenges

[39] European institute for innovation and technology. [Online]. Available: https://eit.europa.eu/

[40] Euratom. [Online]. Available: https://ec.europa.eu/programmes/horizon2020/en/h2020-section/euratom

[41] Participation in fet projects. [Online]. Available: https://ec.europa.eu/programmes/horizon2020/en/news/infographic-participation-horizon-2020-fet-projects

[42] European research council. [Online]. Available: https://erc.europa.eu/

[43] Future and emerging technologies. [Online]. Available: https://ec.europa.eu/programmes/horizon2020/en/h2020-section/future-and-emerging-technologies

[44] Marie skłodowska-curie actions. [Online]. Available: https://ec.europa.eu/programmes/horizon2020/en/h2020-section/marie-sklodowska-curie-actions

[45] Research infrastructure. [Online]. Available: https://ec.europa.eu/programmes/horizon2020/en/h2020-section/research-infrastructures-including-e-infrastructures

[46] Fet open programme. [Online]. Available: https://ec.europa.eu/programmes/horizon2020/en/h2020-section/fet-open

[47] Fet proactive programme. [Online]. Available: https://ec.europa.eu/programmes/horizon2020/en/h2020-section/fet-proactive

[48] Fet flagship programme. [Online]. Available: https://ec.europa.eu/programmes/horizon2020/en/h2020-section/fet-flagships

[49] Fet launchpad programme. [Online]. Available: http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/fetopen-04-2016-2017.html

[50] Human brain project. [Online]. Available: http://www.humanbrainproject.eu/en/

[51] Graphene flagship. [Online]. Available: https://graphene-flagship.eu/

[52] G. Hager and G. Wellein, *Introduction to High Performance Computing for Scientists and Engineers.* CRC Press, 2010.

[53] J. S. Vetter, *Contemporary High Performance Computing: From Petascale toward Exascale.* Chapman and Hall/CRC, 2013.

[54] Hpc fet proactive call. [Online]. Available: https://ec.europa.eu/programmes/horizon2020/en/h2020-section/high-performance-computing-hpc

[55] Eurohpc countries. [Online]. Available: https://ec.europa.eu/digital-single-market/en/news/switzerland-new-ally-european-cooperation-high-performance-computing

[56] Eurohpc. [Online]. Available: http://eurohpc.eu/

[57] Eurohpc declaration. [Online]. Available: https://ec.europa.eu/newsroom/document.cfm?doc_id=43815

[58] J. P. Dowling and G. J. Milburn, *Philos Trans A Math Phys Eng Sci*, vol. 361, p. 1655, 2003.

[59] E. G. Rieffel and W. H. Polak, *Quantum Computing: A Gentle Introduction.* The MIT Press, 2011.

[60] The quantum manifesto. [Online]. Available: https://msu.euramet.org/current_calls/fundamental_2017/documents/Quantum_Manifesto.pdf

[61] Fet eranet cofund in quantum technologies. [Online]. Available: http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/fetproact-03-2016.html

[62] Cordis web page. [Online]. Available: http://cordis.europa.eu/projects/home_en.html

[63] Deep projects. [Online]. Available: http://www.deep-projects.eu/

[64] Twitonomy web page. [Online]. Available: http://www.twitonomy.com/

[65] Montblanc projects. [Online]. Available: http://www.montblanc-project.eu/

[66] Nuvi web page. [Online]. Available: https://www.nuvi.com/

Acknowledgements

This is the fourth thesis of my *curriculum studiorum*. The previous ones were written for my Bachelor's, Master's and Doctoral degrees. Contrarily to the others, this thesis is not on physics and astronomy. However, just like the others, it includes my acknowledgements to the persons who most supported me in this endeavour. I am very thankful to:

- Daniela Ovadia for supervising the work I present in this thesis;
- Elisabeth Schmid and Elena Gaboardi for the possibility to carry out an internship at the youris.com media agency in Milan. It was a unique chance to learn about science communication from motivated professionals and to discover the FET environment, which inspired me for this thesis;
- Alessandra Barbieri from youris.com for running on NUVI the monitoring activity outlined in section 4.3;
- All other colleagues at youris.com I had the pleasure to know and work with: Noemi Ancona, Marcello Bardellini, Giulio Bordonaro, Alice De Ferrari, Angelique Lusuan, Mario Martinoli, Charlotte Michi, Veronica Meneghello, Loredana Pianta and Silvia Raimondi.

And, finally, my wife. Amor, no estábamos casados cuando empecé a trabajar en esta tesis en julio. Ahora que estoy escribiendo sus últimas palabras, sí. No te puedo expresar lo maravillosa que

eres y la felicidad que me embarga el compartir mi vida contigo. Gracias por haberme apoyado cuando decidí empezar este programa de estudios en Roma y durante los últimos meses, en los cuales se sumaron mucho trabajo y viajes cansadores. Y, sobre todo, gracias por entender con sonrisas (y paciencia infinita) mi ser físico teórico del alma, con las bromas aburridas y la lógica insensata que conllevan. Te amo!

Hannover, November 2017