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European Research Projects on Quantum Technologies and High Performing Computing: Analysis of The Communication Strategies

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Abstract

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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 1.3 presents science communication as a requirement for 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 accumulate tangible goods, but rather on the ability to store, generate and apply new knowledge [6].

The information 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 heavily shape our 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]. Just like any other resource, it is important for its 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.

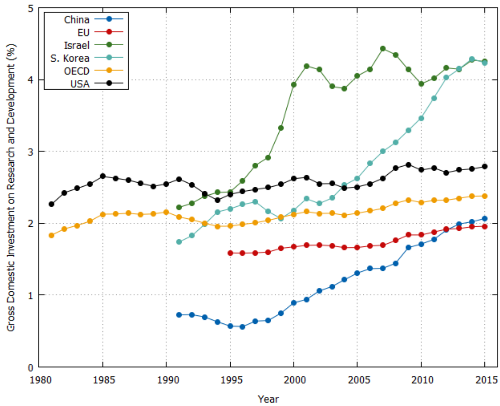

Figure 1.1: Gross domestic percentage invested in science and development over the past years by some of the world's leading economies. The image is based on data of the Organisation for Economic Cooperation and Development (OECD) [9].

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 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

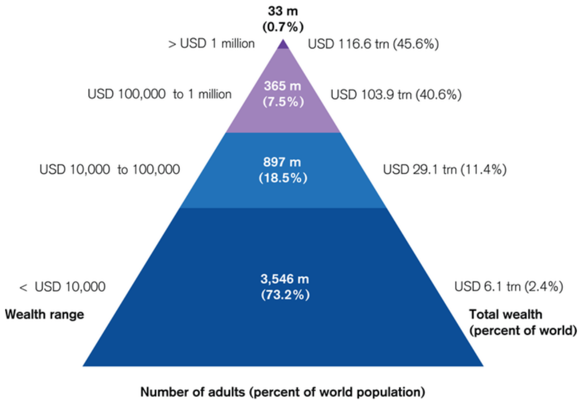

Figure 1.2: Distribution of the global wealth among the world's population. Original image in [12].

a scenario, knowledge as a resource partially looses the intrinsic characteristics mentioned in Section 1.1 of being unlimited and non exclusive.

The current knowledge-driven development of the global economy has two important consequences. Firstly, humanity is richer than ever before [14]. Secondly, 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.

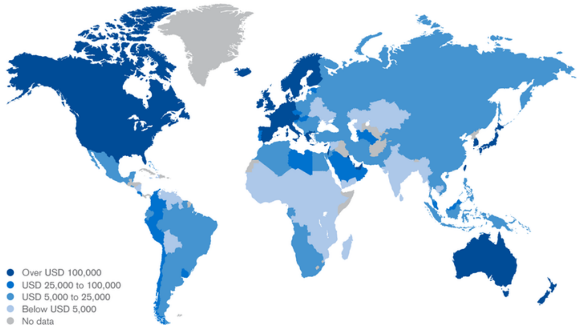

Figure 1.3: Comparison among nations of the current annual wealth per adult. Original image in [12].

1.3 The scientific citizenship

The potential of scientific knowledge to be a pillar of democratic societies was first recognised by English philosopher Francis 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 science permeating role in today's society, science-related issues are no exception [18]. Examples are topics such as mandatory vaccination, 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. To be useful, research results must be 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, citizens etc. Hence, 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 considered communication channel. As a consequence, numerous different kinds of science communication can be identified.

The present 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 Roman poet Lucretius in the first century BC. Another historically very important book was Galileo Galiei's *Sidereus Nuncius* in the XVII century. His work rapidly 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 a specific class of EU-funded research project 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 of the future's most important scientific challenges: the development of quantum technologies and high-performing computers.

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 people's life quality. However, it also presents new 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 on the impact of scientific issues on their lives. This can be achieved by training people to discuss scientific questions in a constructive and critic way, i.e., if 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 adopted to inform citizens via social media of recent developments in European research projects.

Chapter 2

FET in Horizon 2020

This chapter focuses on the FET funding programme. Section 2.1 illustrates the Horizon 2020 initiative. Section 2.2 is a description of FET in the framework of Horizon 2020. Sections 2.3 and 2.4 summarise the FET effort towards the development of quantum technologies and high-performing computers, i.e., the two most important research lines for the scope of this thesis.

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 smart and 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 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 organisation and companies) can apply for Horizon 2020 funding. The main

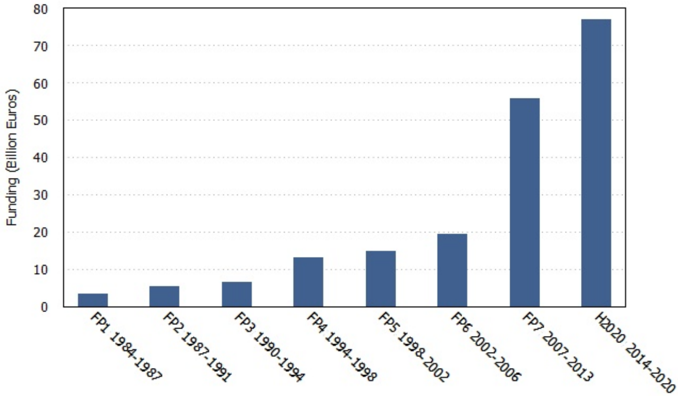

Figure 2.1: Duration and allocated budget of Europe's Research and Innovation programmes (also known as Framework Programmes, FP). Budgets are expressed in billion Euros. Data from [34].

categories into which 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 [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 [36].
- **Societal Challenges:** this category focuses on priorities of the European society such as health, education, energy supply and food by combining knowledge and methods from disparate scientific fields [37].
- **European Institute for Innovation and Technology:**

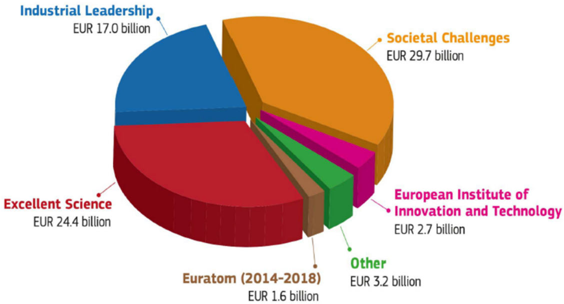

Figure 2.2: Budget breakdown of the Horizon 2020 programme. Original image in [40].

this institute is an independent European body supporting growth via the promotion of synergies in the fields of education, research and business [38].

- **Euratom:** this pillar funds nuclear research in the framework of the decarbonisation of the energy supply [39].

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

2.2 The FET programme

As mentioned in section 2.1, one of the actions of Horizon 2020 is the Excellent Science programme. This initiative 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:

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 Euros. Data from [40].

- **European Research Council:** it distributes funding in every research field to single scientists and with the requirement of scientific excellence [41].
- **Future and Emerging Technologies (FET):** it finances collaborative research exploring visionary and radically new investigation lines [42].
- **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 [43].
- **Research infrastructure:** it promotes the creation of transnational networks of research infrastructures as well as the training of qualified staff [44].

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

This thesis focuses on the communication activity of the 151 FET projects funded to date within Horizon 2020. 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.

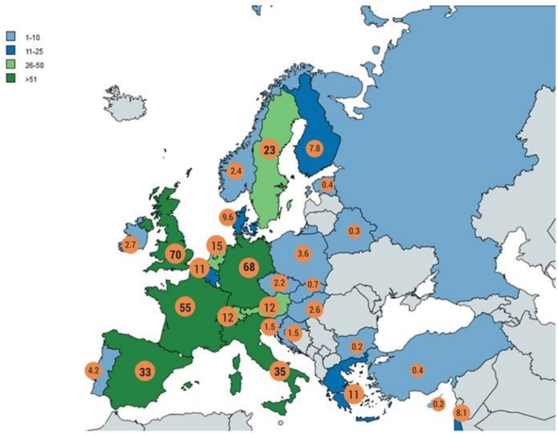

Figure 2.3: Participants in the Horizon 2020 FET programme on a country basis as of June 2016. Numbers correspond to FET funding in million Euros. Colours indicate the number of participants. Adapted from image in [45].

The FET funding scheme 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 FET Innovation Launchpad, which investigates and 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 the birth of synergies on specific research lines by bringing together scientists from interdisciplinary fields. 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 on identifying investigation roadmaps, design and distribute material for educational purposes and disseminate 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 Euros each. The ultimate goals are 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:** it targets groundbreaking steps forward in neuroscience [50].
- **Graphene:** it explores graphene's properties and possible applications [51].
- **Quantum Technologies:** it aims at developing 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 its relevance for this thesis, the Quantum Technologies Flagship is described 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, as it would push forward research and the development of new technology over the next decades [53].

As mentioned in section 2.2, the European HPC effort is funded within the "High Performance Computing" FET Proactive call [54]. This call comprises three initiatives: *i*) co-design of HPC systems and applications; *ii*) transition to exascale computing; and *iii*) exascale HPC ecosystem development. The main goals of the three initiatives are to develop the next-generation high-performing computers towards exascale and to provide access to the resources offered by supercomputers. The list of Horizon 2020 FET projects active in HPC is available in Appendix B.

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 societies.

The so-called first quantum revolution started at the beginning of the past century with the development of 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 [55]. 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 [56]. The urge for Europe to stay at the forefront of the second quantum revolution is outlined in the so-called Quantum Manifesto [57].

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 [58]. 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 funding scheme of Horizon 2020 is Future and Emerging Technologies (FET). 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. The development of quantum technologies is part of the FET effort. 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.

4. Another major goal of the FET initiative is the development 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.

Part II

Analysis and results

Chapter 3

FET projects and social media

This chapter focuses on the presence of FET projects on online communication channels. Section 3.1 describes the analysed sets of projects. Section 3.2 lists the communication channels considered for this thesis. Section 3.3 outlines the search conducted to find the channels on which each FET project is active. Sections 3.4 and 3.5 provide an overview of the usage frequency of online channels made by FET projects. Sections 3.6 and 3.7 investigate the impact of the available budget on the number of online communication channels.

3.1 Data set

This thesis focuses on the online communication activity of FET projects launched within the Horizon 2020 funding scheme. The list of projects was downloaded on 15th July 2017 from CORDIS, the main portal of the European Commission on results of EU-funded research projects [59]. FET projects approved after 15th July 2017 are not considered in this thesis.

The list 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 as the activated online communication channels (see section 3.2 for the channels considered in this thesis).

Some projects in the list were not considered for the present analysis. Excluded groups were the Flagship and Launchpad projects (see section 2.2 for a brief description of the two classes), as well as projects started after 1st February 2017. Disregarded projects are listed in Appendix B. This procedure reduced the data set from 151 to 130 samples.

Flagship projects were not taken into account due to their budget. The funding at their disposal is far superior compared to the other FET projects, see Appendix A. Thus, the Human Brain and Graphene Projects can invest larger resources and were not considered representative of FET initiatives in terms of communication effort.

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

Projects started after 1st February 2017 were not considered as the time span between this date and the list download was judged insufficient to fully develop and launch an adequate communication activity. The only exception is the DEEP-EST project. By the time of writing, DEEP-EST has already started a solid online communication effort.

For some of the investigations in this thesis, the data set of 130 projects was divided into three sub-groups. The first group consists of the 22 projects active in HPC and the transition to the exascale (see section 2.3). The second subgroup includes the 10 projects in the field of quantum technologies (QT, see section 2.4). The third group comprises the other 98 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 results show limited robustness under future changes in the data. Hence, the results reported in this work should serve as a guideline rather than as definitive statements.

3.2 Considered communication channels

The communication channels offering the widest potential audience are based on the internet. Examples are websites and social media. For this reason, online channels are pillars of the FET communication strategy.

Different approaches can be considered to assess the use of online communication channels made by FET projects. One quantitative estimate is the fraction of projects active on specific platforms. For this thesis, the following communication channels were considered:

Website Websites are the online channels offering the highest degree of freedom. They allow the owner to personalise the content, its presentation strategy and 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 science-related communication. It requires high posting rates and offers less personal interaction compared to Facebook.

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

YouTube YouTube is the world's main platform for video sharing. It offers a very direct communication channel, but 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.

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

The analyses presented in this thesis are based on the number of FET projects considering the online communication tools mentioned in section 3.2. To determine these values, a search was performed for all projects in Appendix A.

The search was conducted as follows. First, projects were contacted directly and asked on which channels they are active. However, in many cases it was not possible to find the contact details or no answer was received. This happened for 42 projects out of the 130 of interest for the present analysis (more specifically, for 4 out of 22 HPC projects, 1 out of 10 QT projects and 37 out of 98 other projects). A desk search was then performed to gather the required information for the 42 projects.

It cannot be excluded that the desk search failed to find all websites or accounts activated on the social channels considered for this thesis. Thus, it is highly probable that the list of accounts in Appendix A is 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

Out of the 130 projects in the data set, 124 have created a website, 66 have opened accounts on Twitter, 26 on Facebook, 20 on

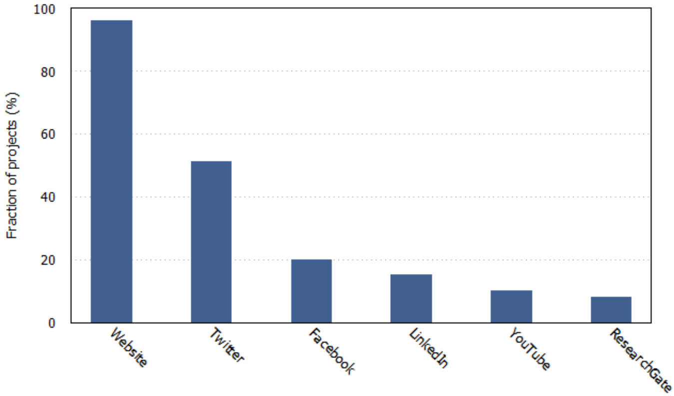

Figure 3.1: Fractions of FET projects making use of the communication channels considered for this thesis.

LinkedIn, 13 on YouTube, 10 on ResearchGate and ... on Instagram. The results, expressed as percentage values, are reported in Figure 3.1.

The results show 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 significantly larger than that on Facebook. This is opposite to what occurs in society, where Facebook is the most used social media. This indicate 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 not familiar with the research field. The difficulty arises from the fact that the objectives and results of FET projects 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.

The number of projects active on ResearchGate is low. This seems to indicate that ResearchGate is not seen as a suitable channel for large-scale communication activity. The reason could be the fact that the reachable audience is typically limited to researchers active in similar investigation fields.

3.5 Online presence breakdown

The analysis in section 3.4 was repeated on the projects sub-groups outlined in section 3.1: HPC, QT and Others. This enabled a comparison of how disparate classes of FET projects make use of online communication channels. The results are shown in figure 3.2.

The figure shows that basically all FET projects have created a website, regardless of the considered sub-group. As for the most used social platforms within the FET community, i.e. Twitter, Facebook and Linkedin, the HPC class has opened the most accounts compared to QT and other projects. The result indicates that HPC projects are among the most active FET initiatives in terms of online communication.

The QT sub-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, robust experiences 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 different strategies. This is the case of HPC and QT projects, which pursue very technical and often interconnected objectives, such as the

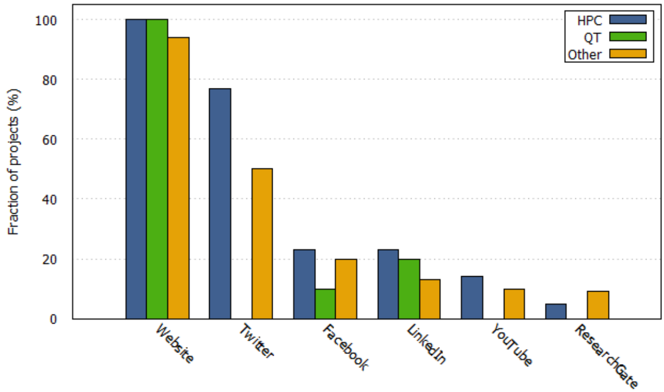

Figure 3.2: Fractions of FET projects making use of the communication channels considered for this thesis. Results are given as a function of the three project classes considered for this thesis. No QT project is active on Twitter, YouTube or ResearchGate.

common goal of improving current computers[1].

3.6 Budget impact

The number of channels considered by projects depends mainly on the pursued communication strategy and the available budget. The two factors are often interconnected, as the former may be heavily impacted by the latter. Thus, it is worth assessing how deeply the online communication activity launched by FET projects is influenced by the allocated funding. One approach in this direction

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

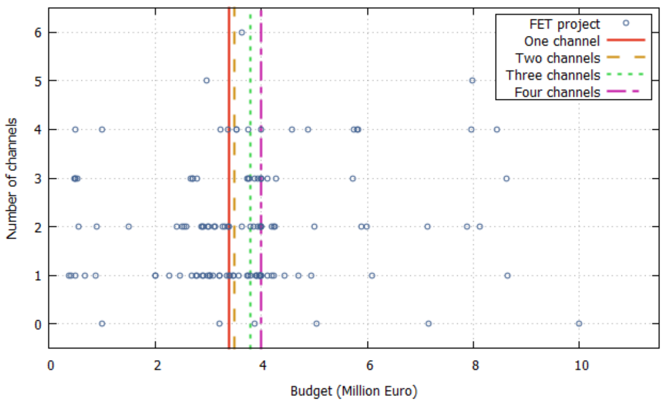

Figure 3.3: Projects' distribution as a function of the available budget and of the number of considered online communication channels. The vertical lines are the budget medians of the group of projects with activated channels ranging between one and four. For the sake of clarity, the figure shows the budget range up to €11.5 Million. The following projects were used for the medians calculation but lie outside the plotted budget range: QuantERA (€40.5 Million, 3 channels), FLAG-ERA II (€18.3 Million, two channels) and DEEP-EST (€15.9 Million, 3 channels).

consists of searching for the dependence of the number of activated channels on the available funds. The results are shown in figure 3.3.

The plot shows that the majority of the projects has activated a number of channels between one and four. Hence, four groups of projects were identified based on the amount of activated channels (from one to four). The other projects were not considered 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

Number of channels	Budget median
One	3.4
Two	3.5
Three	3.8
Four	4.0

Table 3.1: Medians of the projects' budgets as a function of the number of channels considered by the projects. Values are rounded and expressed in million Euros.

values are reported in table 3.1 and drawn as vertical lines in figure 3.3.

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

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

The approach followed in section 3.6 enabled a further comparison of QT and HPC projects. Figure 3.4 shows the two classes as a function of the number of activated channels and available budget.

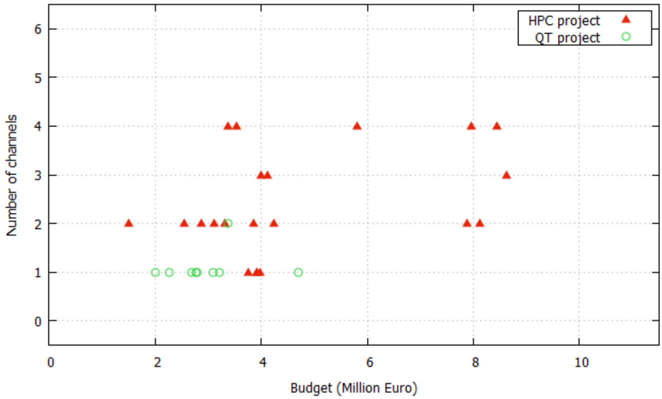

Figure 3.4: Distribution of HPC and QT projects as a function of the available budget and of the number of considered online communication channels. For the sake of clarity, the figure shows the budget range up to €11.5 Million. The QuantERA project (€40.5 Million, 3 channels) lies outside the plotted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

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 considered more communication platforms. The result highlights the different communication strategy followed by the two classes of projects, as mentioned in section 3.5.

3.8 Chapter summary

In this chapter, the following items have been discussed:

1. FET projects make use of several online communication channels. The most used channels are websites, twitter and facebook. Only a limited fraction of projects is active on YouTube and ResearchGate.

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 project have very limited presence on the social platforms considered for this thesis.

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

4. The guideline in the previous point holds for the HPC and QT classes. Selecting projects within similar budget ranges shows that the two sub-groups tend to follow opposite strategies. In general, HPC projects are active on several channels, whereas QT initiatives limit their online communication to the use of the website.

Chapter 4

HPC projects on Twitter

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4.1 Overall activity

The first step for a deeper look at the activity of HPC projects on Twitter was to analyse the activity of the considered accounts since the day they had been opened. The results are collected in Table 4.2. This was done with the Twitonomy application.

Tweets per day

Out of the 17 considered HPC projects, three have an average tweeting rate of more than one post per day whereas 12 post less than once every second day. In particular, one project has posted no tweets since the opening of the account. The median of all projects is 0.16 tweets/day. This corresponds to roughly 5 posts per month. The median was chosen for its robusteness, similarly to what was done in section 3.6. The time distribution of the tweets of the accounts with the highest rates are shown in figures 4.1 and 4.2.

Retweets and retweets times

Another interesting result is the one about retweeted tweets. This corresponds to the percentage of the account's tweets retweeted by other users. The higher this number, the more the user is considered a valuable source of information by others. The table shows that one project had significantly more than half of the tweets retweeted. The median is 23.6%. This data is integrated by the data on the average number of times each retweeted tweet was retweeted. This also indicates how valuable this account is considered by others. In the list in the table, six projects have an average times of retweet higher or equal to two, which means that retweeted tweets are retweeted by more than one user. The median value is 1.67.

Links and hashtags per tweet

Table 4.2 reports also the average number of links and hashtags in the tweets of the considered projects. The higher the former number, the more likely the user is a source of information to others. As for the latter number, the higher it is, the more likely the user's tweets are to be found in a search. The table shows that six projects have an average number of links per tweets higher or equal to 0.5, meaning that they post a link every second tweet. The median is 0.32, i.e. one link every third tweet. As for the number of hashtags, three projects have a number equal or larger than one. The median is 0.25, i.e., one hashtag every fourth tweet.

Comparison to FET profile

Table 4.2 reports also the values for the Twitter profile @fet_eu of the FET funding programme. The number of tweets per day is much larger than the median of HPC projects. The same holds for the number of retweets. Nevertheless, the number of retweets tweets is not significantly larger than the median value for HPC (32% vs 23.6%). The same holds for the number of links per tweets, whereas the average number of hashtags is almost four times larger.

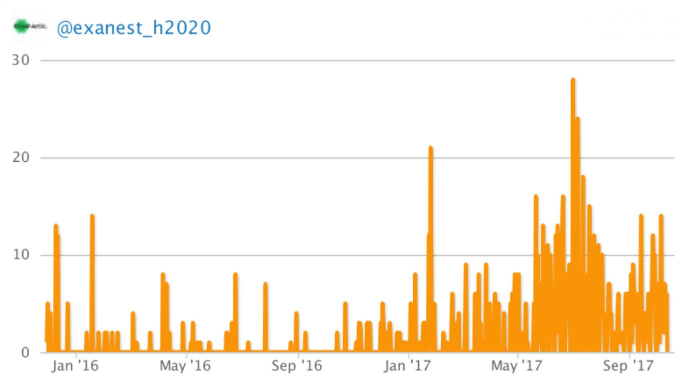
4.2 Influence

To find what are the HPC projects more influent on twitter, the data in table 4.1. Data are updated to 14th October 2017. Influent projects on twitter are identified with the following conditions: high number of followers and high ratio followers/following. These data are were collected with twitonomy and are shown in table 4.1.

The values in the table are shown in figure 4.3. The plot shows that the most influent HPC projects are identified by the conditions followers more than 100 and ratio larger than 2. These two values were identified by calculating the median of the number of followers and of the ratio followers/following of HPC projects. These projects are ExaFLOW, EXDCI, NEXTGenIO and READEX.

4.3 Mentions of HPC projects

A monitoring activity was launched to estimate the impact of HPC projects of Twitter. This was performed with the Twitter Analytics tool NUVI [60]. This activity monitored the mentions of the Twitter accounts of HPC projects from 1st July to 12th October 2017. The monitor activity analysed a total of 1323 social mentions. The time distribution of the mentions is shown in figure 4.4.



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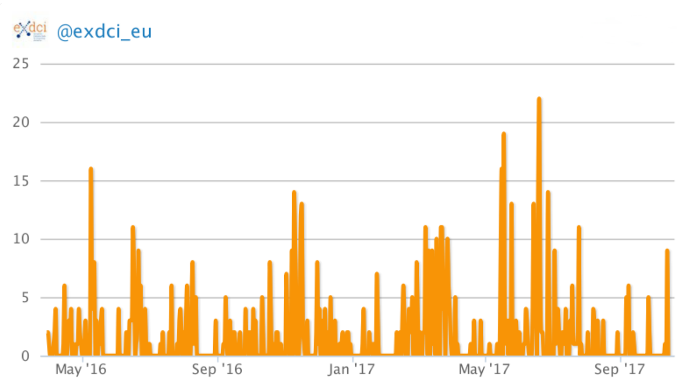
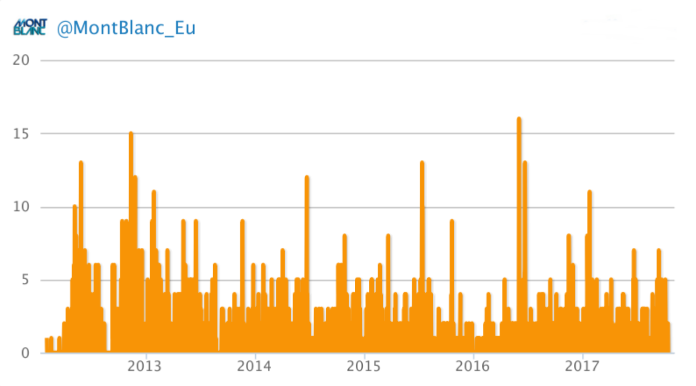


(b)

Figure 4.1: (a) Time distribution of the number of tweets with hashtag #quantumcomputing posted between 7th and 14th October 2017. (b) As for (a) but over the time period between 20th and 25th October 2017.



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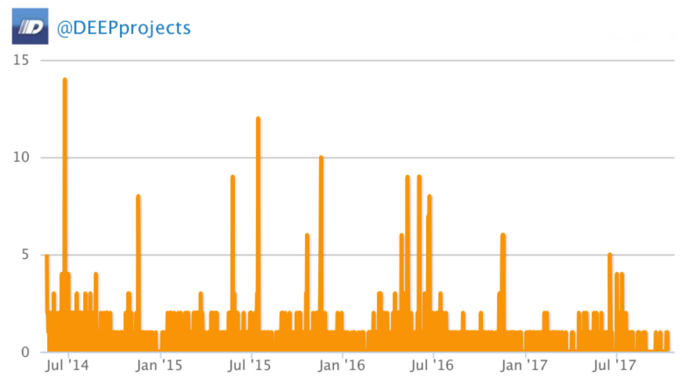


(b)

Figure 4.2: (a) Time distribution of the number of tweets with hashtag #quantumcomputing posted between 7th and 14th October 2017. (b) As for (a) but over the time period between 20th and 25th October 2017.

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 4.1: Summary of the Twitter analytics for the hashtag #quantumcomputing over the monitored time periods. The potential reach is defined as the total aggregate number of followers of the people who mentioned the considered keyword in their tweets.

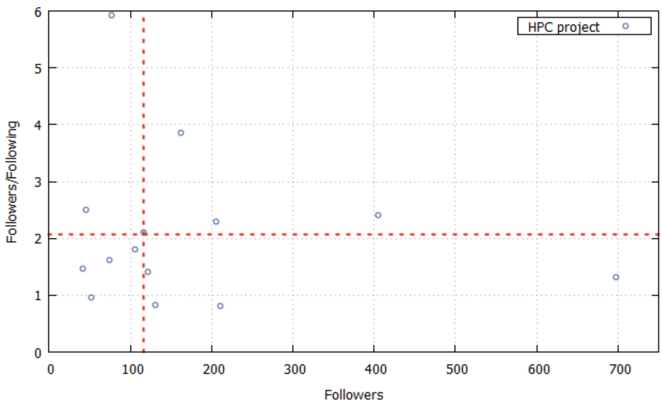


Figure 4.3: Projects' distribution as a function of the available budget and of the number of considered online communication channels. The vertical lines are the budget medians of the group of projects with activated channels ranging between one and four. For the sake of clarity, the figure shows the budget range up to €11.5 Million. The following projects were used for the medians calculation but lie outside the plotted budget range: QuantERA (€40.5 Million, 3 channels), FLAG-ERA II (€18.3 Million, two channels) and DEEP-EST (€15.9 Million, 3 channels).

Project	Start date	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	12.5%	1.38	0.46	0.06
ExaNoDe	20/06/2017	38	0.32	13.2%	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	51.5%	2.18	0.77	0.79
MANGO	03/12/2015	32	0.05	43.8%	1.93	0.38	0.38
Mont-Blanc 3	06/02/2012	2 506	1.21	23.6%	2.68	0.32	0.50
NEXTGenIO	30/09/2015	211	0.28	23.7%	3.02	0.14	0.52
READEX	13/10/2015	29	0.04	69.0%	1.60	0.62	1.03
SAGE	30/09/2015	92	0.12	32.6%	1.77	0.20	0.07
FET	07/01/2016	3 199	4.94	32.3%	4.46	0.42	0.92

Table 4.2: FET projects launched within the Horizon 2020 funding programme as of 15th July 2017. Total and EU funds are expressed in Euros. The links to the websites and Twitter and Facebook accounts were searched for by directly contacting the projects. For some of the projects, no contact details were found or no reply was received. In such cases, a dedicated search for the considered channels was conducted. Some channels may have not been found by the search. Thus, the information in the Table could be incomplete.

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: Summary of the Twitter analytics for the hashtag #quantumcomputing over the monitored time periods. The potential reach is defined as the total aggregate number of followers of the people who mentioned the considered keyword in their tweets.

The peak of conversation happened on 12th September 2017. It consisted of 59 mentions, with the most frequently used keywords during that peak being filippo mantovani, workshop, server cpu, prototype and processors.

Out of the 1323 mentions, 637 were original mentions, which had the potential of reaching an audience of 172 720 users. This reach is calculated as the sum of the followers of the accounts mentioning the analysed keywords. Moreover, 116 unique profiles made a total of 686 reshares. Shares and re-tweets spread the mentions to an additional 233 974 people. The spread is calculated as the sum of the followers of the accounts which shared or retweeted the tweets with the mentions. Reach and spread together give an estimate of the potential audience which came across with the tweeted contents. Figure 4.5 shows the mentions with the largest reach, spread and the most popular one. The ratio between reach and spread defines the viral coefficient, which is equal to 1.4, see figure 4.6. As the value of the viral coefficient is larger than one indicates that the mentions were extremely viral.

An overview of the topics treated in the monitored mentions is provided in figure 4.7. The figure is based on the 1005 mentions which came across 485 major categories over the monitored time. The list of most shared words is in table 4.3.

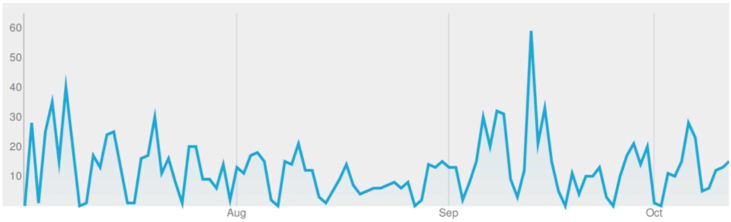


Figure 4.4: Projects' distribution as a function of the available budget and of the number of considered online communication channels. The vertical lines are the budget medians of the group of projects with activated channels ranging between one and four. For the sake of clarity, the figure shows the budget range up to €11.5 Million. The following projects were used for the medians calculation but lie outside the plotted budget range: QuantERA (€40.5 Million, 3 channels), FLAG-ERA II (€18.3 Million, two channels) and DEEP-EST (€15.9 Million, 3 channels).

Figure 4.5: 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 group of projects with activated channels ranging between one and four. 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: QuantERA (€40.5 Million, 3 channels), FLAG-ERA II (€18.3 Million, two channels) and DEEP-EST (€15.9 Million, 3 channels).

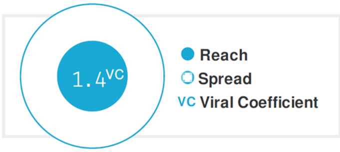


Figure 4.6: Projects' distribution as a function of the available budget and of the number of considered online communication channels. The vertical lines are the budget medians of the group of projects with activated channels ranging between one and four. For the sake of clarity, the figure shows the budget range up to €11.5 Million. The following projects were used for the medians calculation but lie outside the plotted budget range: QuantERA (€40.5 Million, 3 channels), FLAG-ERA II (€18.3 Million, two channels) and DEEP-EST (€15.9 Million, 3 channels).

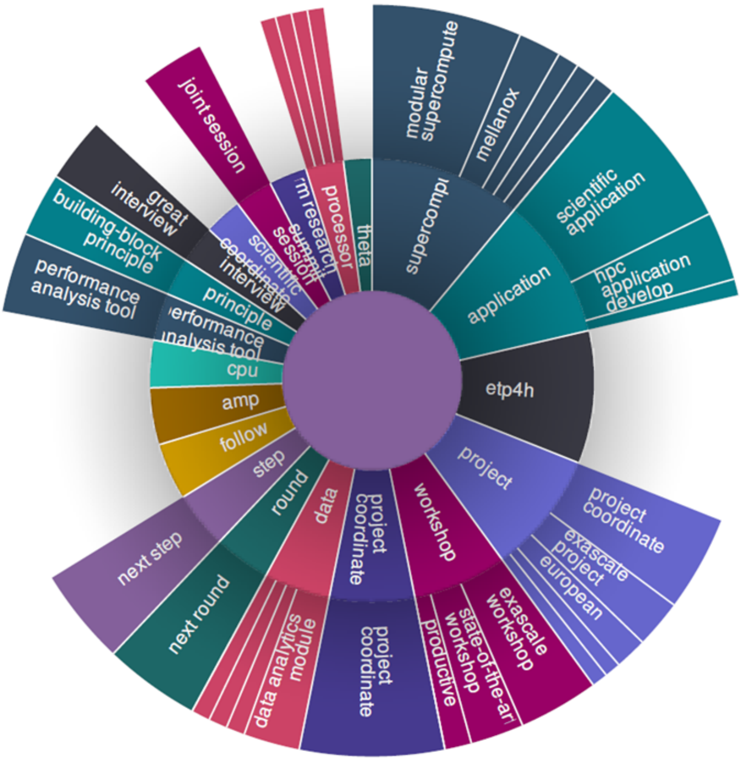


Figure 4.7: Projects' distribution as a function of the available budget and of the number of considered online communication channels. The vertical lines are the budget medians of the group of projects with activated channels ranging between one and four. For the sake of clarity, the figure shows the budget range up to €11.5 Million. The following projects were used for the medians calculation but lie outside the plotted budget range: QuantERA (€40.5 Million, 3 channels), FLAG-ERA II (€18.3 Million, two channels) and DEEP-EST (€15.9 Million, 3 channels).

Chapter 5

The Twitter potential reach of FET projects on quantum technologies

As shown in chapter 3, FET research projects on QTs 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 were 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

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

performed with the Twitter Analytics Tool Twitonomy [61]. The Twitonomy application was also used to obtain all plots and data in this chapter.

HPC was chosen as a suitable topic 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 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.

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

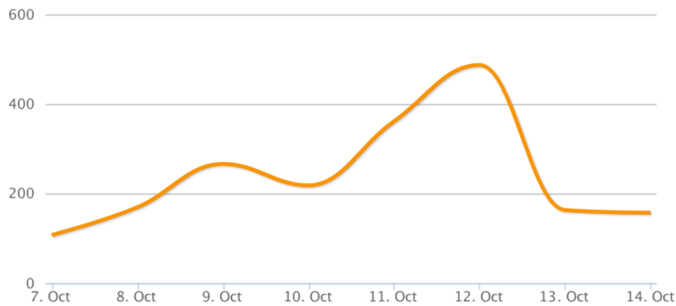
Table 5.1: Summary of the Twitter analytics for the hashtag #quantumcomputing over the monitored time periods. The potential reach is defined as the total aggregate number of followers of the people who mentioned the considered keyword in their tweets.

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 current QT research, see section 2.4.

The monitoring activity covered two periods of time. These ranged from 7th to 14th and from 20th to 25th October 2017, respectively. The time periods were chosen randomly and based on the date ranges which could be handled by the Twitonomy application given the considered volumes of tweets. Different choices of the time periods would not change the order of magnitudes 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 potential 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 keywords. The table shows that #quantumcomputing reaches a potential community of the order of ten million users.



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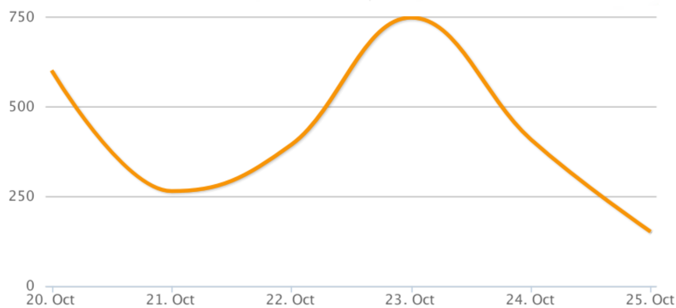


(b)

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

Time period	Tweets	Users	Potential 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: Summary of the Twitter analytics for the hashtag #hpc over the monitored time periods. The potential reach is defined as the total aggregate number of followers of the people who mentioned the considered keyword in their tweets.

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 was chosen as it identifies mentions to the general thematic area.

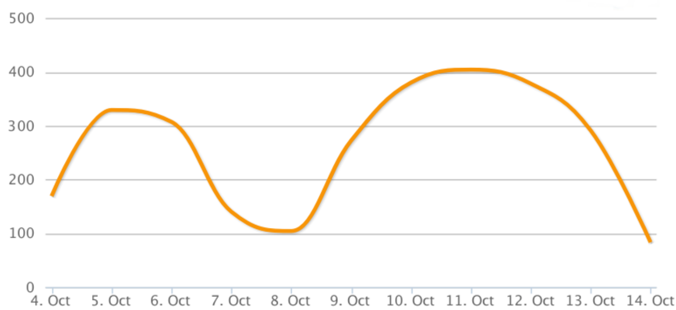
The monitored time periods covered the dates from 4th to 14th and from 15th to 25th October 2017. The time distributions of tweets mentioning the #hpc keyword are shown in figures 5.3. The plots indicate that #hpc is mentioned in hundreds of tweets per day.

An overview of the potential reach achievable with #hpc is available in Table 5.2. Similarly to #quantumcomputing, the potential reach of #hpc is of the order of ten million of users.

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.



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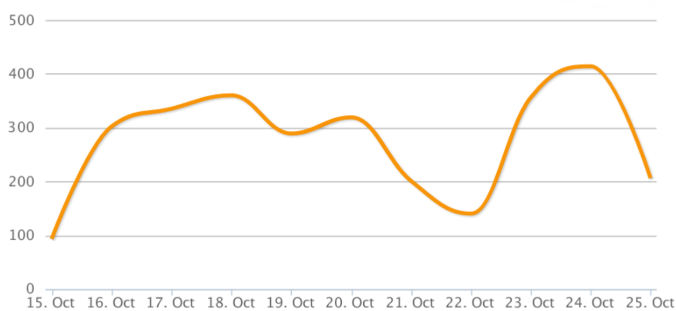
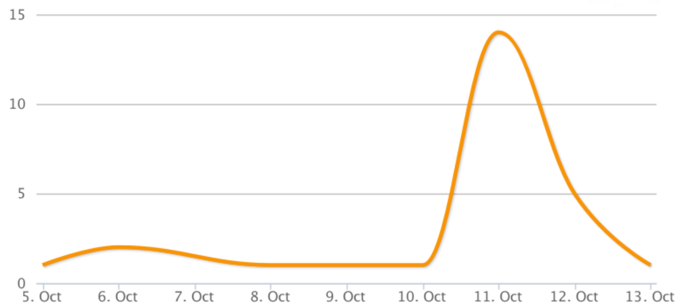


(b)

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



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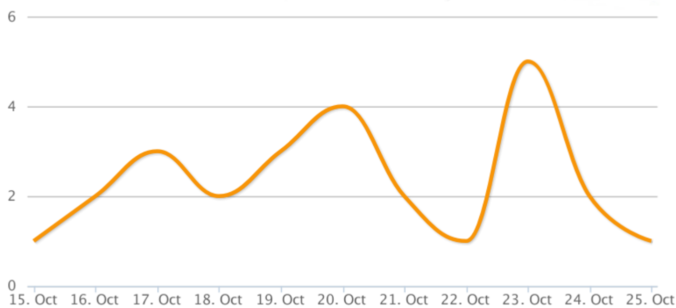

(b)

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

- 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.

It is worth noting that the communities reachable by the #quantumcomputing and #hpc keywords are complementary. This is suggested by the plots in figure 5.4. The plots show the time variation of the number of tweets mentioning both #quantumcomputing and #hpc. The amount of posts is one order of magnitude smaller than those in figures 5.3 and 5.2.

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 increase the number of Twitter profiles reached by FET-funded research by an amount comparable to that offered by HPC initiatives.

5.4 Chapter summary

In this chapter, the following items have been discussed:

1. FET projects on QTs do not make use of 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, the analysis in this chapter indicates that the HPC and QT potential communities share limited overlap in terms of Twitter profiles. 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

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Appendix A

List of FET projects

This Appendix lists all FET projects funded within the Horizon 2020 programme as of 15th July 2017. The list was downloaded from the CORDIS portal [59] and is available in Table A.1. For each project, Table A.1 shows also the start and end date, as well as the total budget and its EU fraction.

This Appendix reports the online communication channels activated by the projects as well. The list of channels considered for this thesis is available in section 3.2. The search performed to find the channels activated by each project is described in section 3.3.

The links to the projects' websites and Twitter and Facebook accounts, i.e., the most common online channels within the FET community, are available in Table A.1. The lists of the accounts activated on LinkedIn, YouTube and ResearchGate are reported in Table A.2, A.3 and A.4, respectively.

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/tiki-index.php # & panel1-1	@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		
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 15th July 2017. Total and EU funds are expressed in Euros. The links to the websites and Twitter and Facebook accounts were searched for by directly contacting the projects. For some of the projects, no contact details were found or no reply was received. In such cases, a dedicated search for the considered channels was conducted. Some channels may have not been found by the search. 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/
2D-INK	in/2d-ink-fet-open-a3b927113?trk=pub-pbmap
ULTRACHIRAL	in/ultrachiral

Table A.2: LinkedIn accounts activated by FET projects funded within the Horizon 2020 scheme. The accounts were searched for by directly contacting the projects. For some of the projects, no contact details were found or no reply was received. In such cases, a dedicated search for the considered channels was conducted. Some accounts may have not been found by the search. 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 FET projects funded within the Horizon 2020 scheme. The channels were searched for by directly contacting the projects. For some of the projects, no contact details were found or no reply was received. In such cases, a dedicated search for the considered channels was conducted. Some channels may have not been found by the search. Thus, the information in the Table may 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.4: ResearchGate accounts activated by FET projects funded within the Horizon 2020 scheme. The accounts were searched for by directly contacting the projects. For some of the projects, no contact details were found or no reply was received. In such cases, a dedicated search for the considered channels was conducted. Some accounts may have not been found by the search. Thus, the information in the Table could be incomplete.

Appendix B

Specific lists of FET projects

Disparate groups 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 preseted 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, Smart-

Nurse, WASPSNEST and WhiteRabbit.

Started after 1st February 2017

CATCH-U-DNA, EuroEXA and FEMTOTERABYTE. The DEEP-EST project was also launched after 1st February 2017. Nevertheless, it was considered for the analysis as it had already activated several communication channels by the time of writing.

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 (HPC)

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 1st February 2017, see above.

Quantum technologies (QT)

AQuS, MaQSens, NanOQTech, QCUMbER, QuantERA, QUCHIP, QUIC, QuProCS, RYSQ and ULTRAQCL. The QUSMI e Qdet projects were not considered as they were launched after 1st February 2017, see above.

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