ATMOSPHERE

Adaptive, Trustworthy, Manageable, Orchestrated, Secure Privacy-assuring Hybrid, Ecosystem for REsilient Cloud Computing

PRELIMINARY RESEARCH PRIORITIES REPORT

DELIVERABLE D2.3

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Author(s):	Rita Meneses (Trust-IT), Rob Carrillo (Trust-IT), Priscila Solis (UnB)
Reviewer(s):	B. Giterman (DELL-EMC) & Altigran Soares (UFAM)
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Disclaimer

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This document contains information on core activities, findings, and outcomes of ATMOSPHERE project. Any references to content in both website content and documents should clearly indicate the authors, source, organisation and date of publication.

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GLOSSARY

Acronym	Definition
CSA	Coordination Support Actions
ESFRI	European Strategy Forum on Research Infrastructures
EU	European Union
EU-BR	European & Brazilian
FAIR	Findable, Accessible, Interoperable and Reusable
GDP	Gross Domestic Product
GDPR	General Data Protection Regulation
HPC	High Performance Computing
ICT	Information Communications Technology
IoT	Internet of things
LGPD	*Lei Geral da Protecção de Dados*
RTD	Research and Technological Development
SIG	Special Interest Group
SM	Smart Manufacturing
SME	Small & Medium Enterprise
SBC	Sociedade Brasileira de Computação
MCTI	Ministry of Science, Technology and Innovation

EXECUTIVE SUMMARY

ATMOSPHERE (Adaptive, Trustworthy, Manageable, Orchestrated, Secure Privacy-assuring Hybrid, Ecosystem for REsilient Cloud Computing) is a 24-month project aiming at the design and development of an ecosystem of a framework, platform and application of next generation trustworthy cloud services on top of an intercontinental hybrid and federated resource pool. The framework considers a broad spectrum of properties and their measures. The platform supports the building, deployment, measuring and evolution of trustworthy cloud resources, data network and data services. The platform is demonstrated on a sensitive scenario to build a cloud-enabled secure and trustworthy application related to distributed telemedicine.

Leveraging the experience gained in past international projects in cloud computing, ATMOSPHERE will furthermore focus on consolidating a sustainable international, European and Brazilian, ICT cooperation activity. By increasing trust in big data cloud computing applications, ATMOSPHERE will contribute to one of the forces influencing both the European and Brazilian economies.

The purpose of deliverable "D2.3: Preliminary Research Priorities Report" is to summarise the EU Brazil joint effort initiatives in cloud computing and report a preliminary analysis of the present challenges and joint EU-Brazil research & innovation opportunities. This analysis is initially supported by another project, the EUBrasilCloudForum Project (https://eubrasilcloudforum.eu/ January 2016-July 2018), which constructed a Final Research Roadmap between Brazil and Europe that was transferred to ATMOSPHERE. The information available in this report is a result of not only desktop research on relevant websites, but also a ~~collectiong~~collection of valuable info that was available in documents focused on EU-BR cooperation in ICT, such as CloudscapeBrazil 2018 event report[1], Cloudscape Brazil 2018 Position papers[2], Blueprint on sustainability of the EU-BR Coordinated Calls within H2020[3] and EUBrasilCloudFORUM Roadmap[4].

In this activity, the project will work with this document as a source, complemented by a set of different activities that includes the research community engagement as well as market and stakeholder inputs. Stakeholders, policy makers and researchers will benefit from this analysis based on joint EU-BR initiatives that also reflect the EU Brazil policy dialogue. This deliverable presents a first version, that summarizes an initial analysis of the major present opportunities and describe the future ones.

[1] Source: https://www.atmosphere-eubrazil.eu/cloudscape-brazil-and-wcn-2018-event-report
[2] Source : https://www.atmosphere-eubrazil.eu/cloudscape-brazil-and-wcn-2018-position-papers
[3] Source: https://www.atmosphere-eubrazil.eu/blueprint-sustainability-eu-br-coordinated-calls-within-h2020
[4] Source : https://eubrasilcloudforum.eu/en/eubrasilcloudforum-research-roadmap

1 INTRODUCTION

Since 2009, Brazil and Europe begin a set of actions to cooperate and develop joint research initiatives in ICT. As part of this collaborative process, an event called EUBR 2009 - I EU-Brazil Cooperation Workshop in Information and Communication Technologies (ICT)), was held on 8-9th September 2009, hosted by the University of São Paulo (USP). The bi-lateral event was co-organised by the Ministry of Science, Technology and Innovation (MCTI) and The Ministry of Foreign Affairs (MRE) of Brazil, jointly with the European Commission Delegation in Brazil and the DG Connect Unit of the European Commission, in partnership with *Fundação de apoio à Universidade de São Paulo* (FUSP), the University of Brasilia (UNB) and the National Education and Research Network (RNP). The purpose of this event was to select, discuss and agree in a workshop setting on the topics for the first ever EU-Brazil joint call for projects in ICT. After this event, in 2010 was launched the 1st Brazil-Europe Coordinated Call in ICT in which five collaborative projects were approved. Then in 2012, the 2nd Brazil-Europe Coordinated Call in ICT was launched, and four projects were approved, included one project in Cloud Computing.

Another EUBR event took place five years after the first event on 28-29th July 2014 in Brasilia, entitled EUBR 2014 – II EU-Brazil Cooperation Workshop in Information and Communication Technologies (ICT). This event co-organised by the Brazilian Computing Society (SBC), the "*Secretaria de Políticas de Informática*" (SEPIN) and "*Ministério Ministério de Ciência, Tecnologia, Inovações e Comunicações*" (MCTIC) of Brazil, the Ministry of Foreign Affairs (MBR), the European Union Delegation in Brasilia and the DG CONNECT Unit of the European Commission. The purpose of this event was to discuss and detail research topics for future cooperation in ICT between Brazil and the European Union, participate in Information Days for future submissions of joint calls and promote the exchange of researchers between Brazil and Europe, and promote networking and future partnerships between Brazilian and European researchers. One of the findings of the EUBR 2014 event and the working group analysis is that a new approach would be required with more regularly occurring EUBR events enabling the coupling of policy dialogues and research and innovations dialogue.

After these activities, in 2015 the 3rd Brazil-Europe Coordinated Call in ICT was launched, with three projects approved in Cloud Computing. One of these projects was the EUBrasilCloudForum[5] project: fostering an International dialogue between Europe and Brazil, which started on January 1st, 2016, which was a Coordination and Support Action (CSA), that had the main goal of mapping and organizing the research and innovation community on Cloud computing at both EU and Brazil sides. The main purpose of the project was to facilitate the policy and technical dialogues between the European Union (EU) and Brazil (BR) in focus areas related to cloud computing, including security aspects. One of the main results of the project was to establish an organisational cooperation forum to enable

[5] Source: www.eubrasilcloudforum.eu

the European Union and Brazil to formulate and develop a common strategy and approach for research and innovation in cloud computing.

The EUBrasilCloudForum project produced a Final Research Roadmap, which is a technical report that makes an analysis and identification of the gaps and research opportunities related to cloud computing, including security, between Brazil and Europe, from 2014 to 2018. The document is based on the outcomes and findings of the EUBrasilCloudFORUM meetings during the 30 months of the project duration and also includes the results and findings of open workshops (Cloudscape Brazil in 2016 and 2017, Workshop on Cloud Networks 2016 and 2017). The report also includes information from position papers and the outcomes of analysis of about 160 European and Brazilian projects related to cloud computing between 2014 and 2018. Finally, the report also gathered and summarizes the outcomes of a survey conducted to capture the opinion and views of two Working Groups the project's Advisory Board.

The Final Research Roadmap produced by the EUBrasilCloudForum project was presented to the Brazilian and European Academic community in July 2018, during the Workshop on Cloud Networks. The document also included a set of topics and recommendations for future collaboration between Brazil and Europe with three different perspectives: research, industry and policy.

Considering that such a report includes a joint view of research interests from Europe and Brazil and may be useful to improve future cooperation and synergies between academia, industry and government, the Atmosphere project, in Work Package 2, defined the delivery of two versions of a Research Priorities Report (D2.3 and D2.5). Then, this deliverable D2.3 presents an initial analysis of the Research Priorities Report, that considers the Final Research Roadmap produced by the EUBrasilCloudforum Project as a source and all the relevant initiatives in EU and BR in these fields in the last year. This includes stakeholder inputs and alignment with the EU Brazil policy dialogue with the purpose of linking research and innovation opportunities and challenges identified with industry firms of all sizes. This document may directly contribute to the next EU Brazil future policy dialogues in 2018 and 2019 since it also includes the inputs from research community engagement activities from different events, for example, the Cloudscape Brazil series organized within the CSBC (Congress of the Brazilian Computer Society) in this year (July 2018). The document also includes the most recent experiences and best practices on cloud computing related to a collection of services platforms, frameworks, software libraries, applications and federated container-based infrastructures.

This deliverable presents in Section 2 the EU Brazil joint initiatives until today, which gives a broad picture of the cooperation in the last years and helps to understand the pillars of this collaboration between Brazil and Europe. Then, in Section 3 the deliverable describes the present challenges and opportunities for joint EU-Brazil research & innovation, based on the Final Research Roadmap and research and input during the last year from different stakeholders and events. In Section 4, the document presents a set of initial

recommendations for EU-Brazil cooperation, that we the Atmosphere project intends to review and improve in the next twelve months. Finally, section 5 presents the conclusions and future works of this task.

2 EU-Brazil joint initiatives in ICT till today

The international cooperation between Brazil and the European Union (EU) in Research and Innovation is based on the Agreement on Scientific and Technological Cooperation which was signed in 2004, came into force in 2007 and was renewed in 2012 for another five years.

Since then, Brazil and EU have been defining cooperation agreements, discussed in forums of political dialogues. Since 2010, Information Communications Technology (ICT) has been a strategic and priority field of cooperation, creating so far 4 coordinated calls. ICT based on mutual priorities and achieve collective benefits in both regions. Over the last eight years, the EU and Brazil have granted in the region of approx. 50 M€ for investment in Research and Technological Development (RTD) activities for ICT.

Today, four calls in ICT have been launched, with 20 projects receiving funding for innovation in relevant key topics for both regions (see *Table 1* EU-BR Coordinated Calls. Additional initiatives have been put in place to support the consolidation of EU-BR joint-innovation, focusing on collaboration in emerging innovation topics (see *Table 2*). These projects had a positive impact in various key areas with positive repercussions on both EU and Brazilian economies.

EU-BR Coordinated Call	Topics	Funds €	Projects
FP7-ICT-2011-EU-Brazil	• Future of Internet; • Microelectronics and Micro-Systems; • Embedded Systems; • E-Infrastructures.	€10 M	• BEMO-COFRA • SecFuNet • FIBRE • OpenBio • PodiTrodi
FP7-ICT-2013-EU-Brazil	• Cloud Computing; • Sustainable Technologies for Smart Societies; • Applications and Services to promote Smart Societies; • Applications and Services for TV in Hybrids Environments, Radio and Bandwidth.	€10 M	• EUBrazilCloudConnect • IMPRESS • GLOBAL ITV • RESCUER
H2020-EUB-2015	• Cloud Computing, including security aspects; • High Performance Computing (HPC); • Experimental Platforms.	€14 M	• EUBrazilCloudForum • SecureCloud • EUBra-BIGSEA • Futebol • HPC4E
H2020-EUB-2017	• Cloud Computing; • IoT Pilots; • 5G Networks.	€16 M	• Atmosphere • 5G-RANGE • OCARIoT • NECOS • SWAMP • FASTEN

Table 1 EU-BR Coordinated Calls

EU-BR Initiative	Goal
INCOBRA	Increase and enhance Research & Innovation (R&I) Cooperation Activities between Brazil and European Union R&I actors, so that both regions get the best value out of the mutual cooperation.
ENRICH (former CEBRABIC)	Supporting and connecting European research, innovation and business organisations to Brazil, thanks to an extensive network of regional innovation hubs and external service providers. Focusing on knowledge-intensive sectors, CEBRABIC will stimulate

EU-BR Initiative	Goal
	collaborative research-to-market projects, ultimately contributing to EU industrial competitiveness.
Dialogues EU-Brazil	Support Facility has the scope of fostering partnerships among Brazilian and European institutions, through projects which facilitate exchanges of experiences, knowledge and best practices, aiming at reinforcing political and technical dialogue around themes of mutual interest.

Table 2 Other EU-BR initiatives

In the following chapters is described, in a succinct way, the main EU-BR funded initiatives in distinct ICT fields, that have been bringing innovation the transatlantic economy.

2.1 EU-BR joint initiatives on Cloud Computing

Cloud computing – services that are accessed directly over the Internet – have been the hottest buzzword in the information technology world. Cloud computing has been a 'game-changer', something that has been changing the industries from different business sectors. It is not surprising that, in all EU-BR coordinated calls, cloud computing was always included as a research & economic priority. Investments are being made in Europe to unleash cloud computing potential, reaching the value of €160 billion to EU Gross Domestic Product (GDP) by 2020 (around 1% of total EU GDP)[6]. In Brazil, the cloud market was U$ 890 million in 2017, with a market growth of 20% compared to 2016[7].

Six European and Brazilian (EU-BR) projects (see Table 3) have been supporting cloud computing market development thanks to their assets. For instance, **SecureCloud project helped to improve trust in cloud computing, thanks to new cloud platform** that was created to support secure resources and facilitate the development of applications, while **ATMOSPHERE focuses on increase trustworthiness on cloud applications**. **EUBra-BIGSEA developed an efficient Big Data Analytics platform supported by self-adaptable cloud services**, which is already implemented on a massively connected societies scenario. **NECOS is solving the limitations of current cloud computing infrastructures** to respond to the demand of new services.

2.2 EU-BR joint initiatives on E-Infrastructures

Digital infrastructures are a must to handle the huge load of connected devices and ensure a successful digital transformation. e-Infrastructures foster the emergence of Open Science, i.e. new working methods based on the shared use of ICT tools and resources across different disciplines and technology domains as well as sharing of results and an open way of working together[8].

The European approach to research infrastructures has made remarkable progress in recent years with the implementation of the European Strategy Forum on Research Infrastructures (ESFRI) roadmap, integrating and opening national research facilities and developing e-

[6] Source: https://ec.europa.eu/digital-single-market/en/european-cloud-computing-strategy
[7] Source: http://ustore.com.br/computacao-em-nuvem/computacao-em-nuvem-mercado-que-nao-para-de-crescer/
[8] Source: https://ec.europa.eu/digital-single-market/en/e-infrastructures

infrastructures underpinning a digital European Research Area. However, Brazil needs to increase investments in its digital infrastructure, since is far behind Europe in this matter.

Four EU-BR projects and other initiatives (see Table 4) focus on e-Infrastructures. **FIBRE developed a new test bed that is being used by universities and research centres**, to integrate major infrastructures in Brazil. This platform, equipped with a new set of services, is preparing the next-generation of researchers to deal with the challenges of the current Internet. **EUBrazilOpenBio produced meaningful results for biodiversity field. The Biodiversity scientific community has been benefiting from access to rich data infrastructures (reports, graphics, maps, and many others) to carry out quality analysis**. By deploying a hybrid e-Infrastructure of open access resources, the European and Brazilian scientific community are now able to access an even greater biodiversity knowledge base, achieved through the integration and shared use of appropriate computing resources. E**UBrazilCloudConnect developed a new middleware for cloud federation**, called Fogbow. It was designed and implemented, as a toolbox to develop complex distributed applications on top of a federated cloud infrastructure which enabled the implementation of three complex applications**. BELLA programme is building a direct submarine cable between Europe and Brazil,** providing the transatlantic data-sharing needs of the European and Latin American research and education communities for the next quarter of a century.

2.3 EU-BR joint initiatives on Microelectronics & Smart Manufacturing

The era of smart manufacturing (SM) and Industry 4.0 promises significant opportunities to reduce cost, boost productivity and improve quality in microelectronics manufacturing. These technologies can leverage big data infrastructures, improve **s**upply chain network integration and cyber-physical systems, amongst others, from distinct business sectors such as: automotive, energy, healthcare and industrial automation.

Europe is in a strong position to advance its microelectronics industry. The EU already boasts leading industries that rely on advances made by electronics design and manufacturing[9]. In Brazil, microelectronics segment still has a long way, due to the scarcity of private investment. It demands a public effort to develop technological knowledge and productive potential[10].

Two EU-BR projects and other initiatives (see Table 5) focus on Microelectronics & Smart Manufacturing. **PodiTrodi created an easily-used, portable-technology platforms assist researchers and clinicians to reach an immediate diagnosis and discrimination of infectious diseases**. Easily-used, Portable-Technology platforms assist researchers and clinicians to reach an immediate diagnosis and discrimination of infectious diseases. **FASTEN is implementing sophisticated software technologies for self-learning, self-optimizing, and advanced control will be applied to build a full connected additive manufacturing system**.

[9] Source: http://www.semi.org/en/6-key-takeaways-iss-europe-2018
[10] Source: http://www.abepro.org.br/biblioteca/enegep2014_TN_STO_197_118_24984.pdf

2.4 EU-BR joint initiatives on IoT and Smart Cities/Societies

- **Global ITV (2nd call):** this project proposed an interactive TV platform that enables coexistence of different systems, offering new global business opportunities for consumer eletronics and media content for transcending the boundaries of broadcast systems. The mission of the project was to develop an interoperability scheme for the co-existence of multiple interactivity and Connected TV solutions on different Digital TV platforms (such as ISDB-Tb, DVB-S/-T/-C and IPTV). This included exchanging and using the same information as well as gaining access to the same content sources, by creating solutions to decrease the efforts for adapting services to multiple platforms and to ease access to a global market for all, allowing the reuse of interactive content worldwide.

- **Impress (2nd call):** this project had the goal of supporting the smart society through a wider adoption of intelligent ICT systems and increasing awareness of energy efficiency. The mission of the project was to provide a systems development platform to enable the rapid and cost-effective development of mixed criticality complex systems involving Internet of Things and Services (IoTS) and at the same time facilitate interplay with users and external systems. IMPReSS platform focused on energy efficiency systems addressing the reduction of energy usage and CO2 footprint in public buildings, enhancing the intelligence of monitoring and control systems as well as stimulating user energy awareness.

- **RESCUER (2nd call):** this project defined a a new trend in the market of software solutions for emergency and crisis management by supporting mobile crowdsourcing information (semi-)automated data analysis, and ad-hoc communication. The goal of the project was to develop a smart and interoperable computer- based solution for supporting emergency & crisis management, with a special focus on incidents in industrial areas & large-scale events, benefiting all players in an emergency.

- **OCARIoT (4th call):** this project has the goal to promote the improvement of eating and physical disorders and the prevention of the obesity onset for children (between 9 and 12 years old). Child obesity is the major pediatric public health concern, affecting around 224 million school-age children in the world. Childhood obesity already affects more than one in three school-aged children in Brazil, Greece and Spain. OCARIoT will develop an IoT-based personalised coaching solution guiding children to adopt healthy eating and physical activity behavior. The IoT network will allow observing child activity patterns of daily living, health evolution, physiological & behavioral parameters and environmental data. All this information combined with medical patterns will allows OCARIoT to provide a customised obesity coaching plan while enabling children to remain active and engaged in their well-being and healthy habits management. OCARIoT will demonstrate and validate its results on three specific pilot sites in Spain, Greece and Brazil. The OCARIoT consortium will ensure children's rights and data privacy, security

and confidentiality through an Ethics Board composed by healthcare professionals and children representatives from different EU and Brazil organisations.

- **SWAMP (4th call):** this project will develop a high-precision smart irrigation system concept for agriculture. The main objectives of the project are reducing effort in software development for IoT-based smart applications, automating advanced platforms and integrating different technologies and components, promote the integration of heterogeneous and advanced sensors, particularly flying sensors (drones) providing precision in the water supply for irrigation. Also, the project will use of a Software Platform together with technologies such as IoT, Big Data, Cloud/Fog and drones for the deployment of pilot applications for smart water management. The project will propose, test and validate new business models for using IoT in smart water management settings.

2.5 EU-BR joint initiatives on High Performance Computing

- **HPC4E (3rd call)**: this project aimed to apply the new exascale HPC techniques to energy industry simulations, customizing them, and going beyond the state-of-the-art in the required HPC exascale simulations for different energy sources: wind energy production and design, efficient combustion systems for biomass-derived fuels and exploration geophysics for hydrocarbon reservoirs. The main goals of the project were to apply the new exascale HPC techniques to improve exploration of 3 different energy industries: wind, biomass-derived fuels and geophysics for hydrocarbon reservoirs; to make efficient use of the future 100 Petaflops and Exaflop systems; to benefit the energy sector from mature energy-oriented simulation toolsets and to benefit vendors from production-ready demonstrators that justify the need of supercomputers.

2.6 EU-BR joint initiatives on 5G and other networks

- **5G-Range (4th call):** this project has the goal to **d**esign, develop, implement and validate the mechanisms to enable the 5G network to provide an economically effective solution for Internet access for remote areas. 5G is considered the next revolution in communication. Several researches focus efforts in tackling challenges for enhancing data rate, reducing latency, improving connectivity and reducing consumption. However, there is one relevant mode that has not been strongly supported by the research efforts, which is Internet access for remote areas. The goal of 5G-RANGE is surpassing the limitations of current technologies, making the coverage of low populate areas a feasible business. Clearly, this new 5G mode needs to be flexible to comply with different applications and services. The project will **i**ntegrate state-of-the-art in mobile communication with business concepts of sharing economy, create a cell radius above 50 km with at least 100 Mbps at the edge, employing both licensed and unlicensed frequencies, while cognitive radio techniques will be used to protect incumbents. Also, the project will combine

innovative PHY and a cognitive MAC, to result in a 5G mode able to reach the unconnected people, not only in Brazil, but worldwide.

- **FUTEBOL (3rd call)**: this project will develop and deploy research infrastructure, and an associated control framework, for experimentation that enables experimental research at the convergence point between optical and wireless networks. The project aims to **d**eploy facilities to be accessed by external experimenters for experimentation that requires integration of wireless and optical technologies. The project also will develop & deploy a converged control framework for experimentation at the optical/wireless boundary and conduct experimental research using optical/wireless facilities.

2.7 EU-BR other joint initiatives

There are other EU and Brazilian initiatives (see Table 6) which focus is to increase international collaboration between Europe and Brazil, namely in the research and industry fields.

EUBrasilCloudFORUM main goal was exactly this. The project was able to **create a Special Interest Group on Cloud Computing**, within the Brazilian Computing Society (SBC SIG), during the second half of 2017. The founding members are European and Brazilian experts in ICT from different sectors, who will work together to discuss Cloud Computing solutions for both regions and provide a structure for the research community in the forthcoming years. The project created the **EUBrasilCloudFORUM marketplace, an online meeting point with a collection of all outputs and players regarding ICT, since international co-operation between Europe and Brazil started.** The marketplace displays the value of using cloud-based services and demonstrates how the results of EU-BR collaborations have impact on and are useful to bigdata, cloud, IoT, HPC and many other sectors. Likewise, ATMOSPHERE and EUBrazilCloudConnect, the project **organised ClouscapeBrazil events. It is the perfect forum for Policy makers, and Research and Industry representatives from Europe and Brazil to debate on hot topics in Cloud computing and ICT co-operation.** These have helped shape cloud developments in Brazil and Europe, by providing insight into current market trends, highlighting the challenges which can slow down the mainstream adoption of cloud services and the best practices to address them, which has now become an integral part of the Sociedade Brasileira de Computação (SBC – Brazilian Computing Society) annual event agenda.

ENRICH encourages and facilitates the cooperation in research, technology and entrepreneurship between Europe and Brazil by supporting and empowering all innovation actors (public & private) along the innovation (value) chain. **INCOBRA project as a similar goal, since it focuses on focus, increasing and enhancing Research & Innovation Cooperation Activities between Brazil and EU Research & Innovation actors**, so that both regions get the best value out of the cooperation. Finally, **EURAXESS promotes researcher mobility and cooperation, by serving researchers of all nationalities, all disciplines, and at all career stages**. This initiative provides regular, tailored and reliable information and organises networking and information events.

3 Present challenges & Opportunities for joint EU-Brazil research & innovation

Brazil and Europe are highly engaged in moving forward ICT development in both regions and have been working together to formulate a common strategy in research and innovation in ICT technologies, and namely cloud computing. However, to consolidate this cooperation, some relevant challenges must be addressed, to achieve more ambitious goals in the future.

The following challenges and opportunities are related on how to transform both Europe and Brazil in to Digital Societies, followed by a recommendation.

3.1 Challenges & Recommendations for Cloud Computing

3.1.1 Trustworthy Cloud Computing & Secure digital environments

Connectivity through the Internet has yielded businesses everywhere tremendous productivity and profitability opportunities. The hitch in this otherwise welcome world is great vulnerability to cyberattacks. If we focus on cloud computing, **despite its rising rates of adoption, the lack of trust is still holding back further Cloud adoptions**[11].

According to Microsoft, "Trustworthiness" is based on 4 important principles: Security, Privacy, Compliance and Transparency. Security covers Confidentiality, integrity and availability, while Privacy is that data cannot be used without owner's approval, Compliance is how, the data is managed and stored according to applicable laws, regulations and standards and Transparency is the visibility over the use of data. These are the four ingredients for a company to be successful in cloud and ensure trustworthiness[12].

Cloud developers need to take security measures to protect their users' sensitive data from cyber-attacks, since the main goals of cyber-attacks against cloud computing are getting access to user data and preventing access to cloud services. Both can cause serious harm to cloud users and shatter confidence in the security of cloud services[13]. **Companies, citizens and governments shall protect themselves against cyber-attack, by becoming "cyber-resilient"**. That is, with "the ability to anticipate, withstand, recover from and adapt to adverse conditions, stresses, attacks or compromises on systems that use or are enabled by cyber resources".

According to 2018 Cloud Security Report[14], the biggest security threats in public clouds are the misconfiguration of the cloud platform (62%), unauthorized access (55%), hijacking of accounts (47%) amongst others (see Figure 1). Regarding the biggest challenges on protecting cloud

[11] Source: https://www.cloudindustryforum.org/content/lack-trust-holding-back-further-cloud-adoptions-finds-cloud-industry-forum
[12] Source: https://www.slideshare.net/ATMOSPHERE2/cloud-trust-107651699
[13] Source: https://www.apriorit.com/dev-blog/523-cloud-computing-cyber-attacks
[14] Source : https://pages.cloudpassage.com/rs/857-FXQ-213/images/2018-Cloud-Security-Report%20%281%29.pdf

workloads, the visibility into infrastructure security (43%) and compliance (38%) were the most mentioned ones. This reinforces the message of how important is to become cyber-resilient.

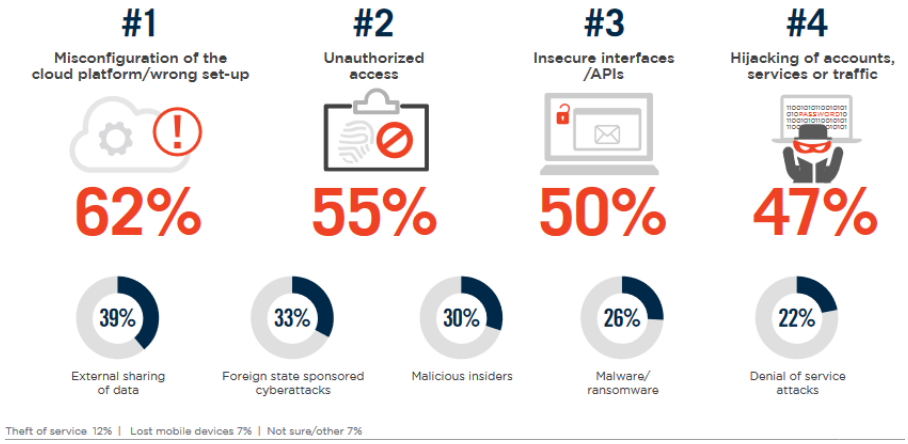

Figure 1 What do you think are the biggest security threats in public clouds? (Source: Cloud Security 2018 Report)

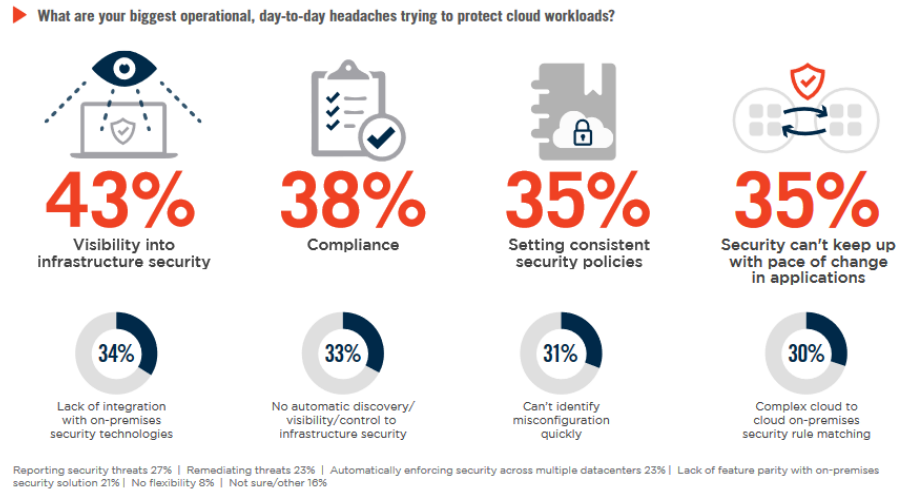

Figure 2 What are your biggest operational, day-to-day headaches trying to protect cloud workloads? (Source: Cloud Security 2018 Report)

Increasing trust on cloud and its risk of cyberattacks will allow the development of distinct business sectors as well, namely on eHealth. Health data will be collected by personal IoT devices and made available on the cloud, allowing real-time monitoring of health. Big Data analytics will have to deal with these large amounts of sensitive data, without compromising data trustworthiness.

There are many differences between Europe and Brazil regarding the legal framework for privacy management in cloud computing and cloud-related technologies (e.g., fog computing, IoT, and edge computing). In fact, privacy-related regulations in Europe are more advanced in

terms of definition and implementation. Also, priorities between EU and Brazil are not always aligned in terms of security/privacy/infrastructure needs. This is an area that needs to be addressed in cooperation between the two regions, in an integrated fashion supported by all of the relevant stakeholders including research, industry, and policy makers. Current limitations in the technologies for secure processing may require rethinking big data programming models for building scalable and secure applications. New approaches for big data processing that allow specifying, enforcing and monitoring privacy policies are needed. Policies that enforce application developers to handle personal data adequately should be put in place. It is important to mention that there is a clear requirement for the automatic or semi-automatic policy enforcement, where the policy control logic /rules are executed without "human intervention".

Furthermore, "risk assessment in the cloud environment" (52%) and "monitoring for compliance" are ranked as top challenges (58%) were the top challenges mentioned by organisations, when they move from their traditional datacenters to the cloud. It is crucial that companies work close with Cloud Service Providers, to ensure that that all policies and regulatory requirements are compliant (see Figure 3). Application developers and their users should be aware of the risks when data is not handled in a secure and privacy-friendly way.

Figure 3 Which part of the cloud compliance process is the most challenging? (Source: Cloud Security 2018 Report)

Considering the above, is crucial the development of a common legal framework for ensuring data privacy aspects (data protection and portability, regulation of international transfer of personal and critical data) in cloud computing, especially in the context of big data processing. This also includes the design and develop a technological framework providing services for privacy-centred big data processing on the cloud (Privacy as a Service) and guidelines for helping application developers to design and develop secure and privacy-friendly applications

(supporting security-by-design), including policies for forcing developers to apply the required practices. Another important action is to **develop** a framework for data collection and protection regulations between EU and BR, as the way forward to cross-regional innovation.

RECOMMENDATION

Increase Security and Trustworthiness on Cloud and cyber-resiliency of companies, citizens and governments.

3.1.2 Cloud to the Edge

Large and centralized clouds have been deployed and have shown how this paradigm can greatly improve performance and flexibility while reducing costs. There are, however, many issues requiring solutions that are user and context aware, dynamic, and with the capability to handle heterogeneous demands and systems in edge computing. Pushing the IoT intelligence, data analytics, and knowledge generation to the edge strongly requires lightweight, energy efficient, and scalable cloud-based solutions that can be dynamically located and managed, on demand and with self-organization capabilities, which are not available nowadays.

Cloud to the edge has the potential to provide an enormous amount of resources, but it raises several research challenges related to the resilience, security, response time, data portability and usage, as well as energy consumption of battery powered devices. Pushing computation to the source of data also raises QoS related challenges, namely ensuring that the edge nodes are not overloaded with computationally intensive workloads, to guarantee the minimum level of QoS expected by the users. Thus, a resource management and load balancing solution with a thorough knowledge of the edge nodes peak hours of usage is required, in which the loads can be efficiently partitioned, scheduled, and rescheduled in a flexible manner. The edge computing can be widely used only if responsibilities and risks of all parties involved are articulated, thus, there are needs for standards to define the social, legal and ethical aspects of using edge nodes.

There in the need to develop innovative approaches to create, configure and manage time varying edge clouds and explore self-* (adaptation, organization, healing, etc.) techniques and tools, which are able to support the deployment of context aware, dynamic, and complex Cloud based systems, and ensure high QoS. This will also create the need develop standards and legal frameworks, in light of all stakeholders and with the help of academic institutions, for all legal and ethical aspects involved with using edge nodes.

RECOMMENDATION

Develop innovative approaches to create, configure and manage time varying edge clouds, up to the case where each Internet connected device is a cloud provider/member, going beyond the fog paradigm .

3.2 Challenges & Recommendations for E-Infrastructures

3.2.1 Cyberinfrastructure for e-science

To keep with the pace of the growing demand for connectivity, cyberinfrastructures are a must. Taking advantage of very-high-bandwidth Internet connections, cyberinfrastructures allows users to connect remotely to supercomputers, electron microscopes, particle accelerators, and other expensive equipment so that they can acquire data and work with distant colleagues without traveling. Plus, the demand for management of sensitive data is expected to increase substantially in the future, in line with increased demand for high-performance computing and data storage.

Due to the increase of global connectivity and large data sets of information (e.g HPC), **it is important to create cyberinfrastructures to allow e-science, that is data processing, storage and analysis, that can be visualized by researchers and organisations and, therefore, create added value for science and research**. e-Infrastructures address the needs of European & Brazilian researchers for digital services in terms of networking, computing and data management by fostering the emergence of Open Science[15]. Climate research, biology, bioinformatics, medicine, chemistry, physics, materials science, energy research and linguistics are a few of the various subject areas that all make use of e-infrastructure[16].

3.2.2 Transatlantic environments for advancing education and experimentation

The use of cloud-based technologies within Brazilian and European for advanced education and experimentation is still low, though there has been an increasing collaboration among research groups between Brazil and Europe. There are no specific education or scientific platforms in which scientists can form groups based on their interests and share scientific resources**. Around the world, hundreds of millions of people lack access to quality learning opportunities**. In Brazil, many of them are children who live in communities where basic educational resources are unavailable. There is a need to advance in education in rural and poor communities providing specific facilities for quality learning.

The future of work and market demands has brought the concept of lifelong learning. The education sector is the 2nd largest sector globally and will increase its scale in the forthcoming years. Several countries are already developing cooperative platforms for education and training, especially in developed countries in which institutions of higher learning are also making efforts to support and inspire lifelong learning and workforce resilience. However, for such efforts to succeed and to increase the efficiency of resources and applications, there is a need to have collaborative environments and exchange of methods and applications between different countries and regions.

[15] Source : http://einfracentral.eu/basic-page/about-einfracentral
[16] Source: https://www.forskningsradet.no/prognett-infrastruktur/Einfrastructure/1254036641061

Considering the above, one recommendation is to develop architectures and solutions to allow the use of cloud computing resources to foster quality learning and education, even in rural areas where access networks are not highly available. This includes the development of innovative educational technologies based on cloud computing, integrating portability, trustworthiness frameworks, artificial intelligence, and deep learning techniques as well as the development of cloud-based architectures for advanced education and experimentation. This includes to design solutions for processing and data sharing scientific data in a secure manner and respecting the applicable regulations, but that allow, at the same time, different groups to take advantage of common and complementary datasets.

RECOMMENDATION

Build more eInfrastructures facilities to promote transatlantic data-sharing for research, industry, advance education and experimentation

3.3 Challenges & Recommendations for Smart Industry

3.3.1 Smart Manufacturing

The current transformation of the industry toward digitization is in full swing. Industry 4.0 not only drives new technologies and intelligent products, but also serves to expand the production sector. This also creates conditions for mastering the ever-increasing dynamics and complexity of existing and new markets[17]. Industry 4.0 not only means a change in production and expansion of technologies, it also means there is an increasing need to create new business models.

Industry 4.0 not only creates products with high added value, but also promotes environmentally and socially sustainable manufacturing. For Industry 4.0 technologies to be deployed at scale, a strong focus needs to be placed on SMEs. Estimates suggest that digitalisation allows for around €110 billion in additional economic output to be generated annually in Europe[18]. In Brazil, the annual estimate of reduction of industrial costs, from the migration of the industry to the concept 4.0, will be at least R $ 73 billion / year[19].

SM finally makes possible to get the right data to the right place at the right time, so operators and business leaders can make better-informed decisions. The data no longer must be directed to a person -- it can be sent to a machine that is learning as things are happening, notifying a person only when necessary[20]. It takes the most of data potential, since it is streamlined and automated.

In fact, smart factories increase output, quality, and consistency. Manufacturers can predict and resolve maintenance issues before they lead to downtime or product-quality issues and identify

[17] Source : http://www.analog.com/en/technical-articles/how-important-is-industry-4-0-for-the-electronics-industry.html
[18] Source : https://www.plattform-i40.de/I40/Redaktion/EN/Standardartikel/international-europe.html
[19] Source : http://www.industria40.gov.br/
[20] Source : https://www.forbes.com/sites/forbestechcouncil/2018/03/19/the-anatomy-of-smart-manufacturing/#2bd86b4c6a6c

waste and increase forecast accuracy when their operations and enterprise systems are connected.

How to become "smart" in manufacture? It does not necessarily require new equipment. There are approaches to introducing web connectivity as an add-on to an existing installation. This can help to lower the cost of entry to smart manufacturing, especially in cases where the installed equipment may contain large numbers of sensors that are used for basic process control[21].

The smart manufacturing transformation begins with IoT[22]. IoT-enabled devices send performance-related information via sensors over a network. During the early-adoption phase, many manufacturers struggle to build IoT applications and integrate them with disparate business applications. Smart manufacturing development is inevitable connected to IoT one.

RECOMMENDATION

Support investments & research on smart manufacturing to empower companies to improve key performance indicators like productivity, equipment uptime and product quality

3.3.2 IoT as a trigger of new digital markets

Internet of things (IoT) is known as being able to accelerate improvements in productivity, cost efficiency, and business performance[23]. According to a European Commission study the market value of the IoT in the EU is expected to exceed one trillion euros in 2020. Brazil approved the "IoT National Plan13", a study with more than 70 initiatives for innovation, human capital, regulatory environment, and connectivity. It **defined 4 domain areas for IoT development in Brazil**: smart cities, health, rural and industries.

In 2025, worldwide**, IoT alone will be responsible for 4-11 trillion dollars of the global economy**, through its application in distinct settings, such as cities, retail, vehicles, homes, and offices, agriculture, among others[24]. For instance, **IoT can be a very useful technology for smart cities** and trigger new digital markets. Cities can connect physical objects and places with interactive digital content and streamline communication between citizens, visitors and the city.

IoT has a positive impact in business sectors, previously not connected at all with, namely agriculture. **The IoT is set to push the future of farming to the next level.** Smart agriculture is already becoming more commonplace among farmers, and high-tech farming is quickly becoming the standard thanks to the use of distinct but complimentary technologies (e.g. IoT, Cloud Computing, Big Data Analytics and artificial intelligence). The sector has been able to digitise the market and get value from data.

[21] Source : https://www.digikey.it/en/articles/techzone/2017/mar/making-legacy-automation-smart-manufacturing-revolution
[22] Source : https://blogs.oracle.com/5-benefits-of-shifting-to-smart-manufacturing
[23] Source : https://www.capgemini.com/2018/03/the-importance-of-industry-4-0/
[24] Source: https://www.atmosphere-eubrazil.eu/cloudscape-brazil-and-wcn-2018-event-report

Despite the potential of IoT, some challenges remain. The design and setup of complex IoT structures requires equally complex approaches and techniques. There still problems of scale, the interoperability at different layers and the increased concurrency of access to the infra-structure, among others. Investments on IoT will unlock market development and support the society digital transition.

IoT is rife with cybersecurity challenges. Although device manufacturers are catching on to the threat, we need better standardization and regulation protocols. We need to have a robust regulatory framework in place to ensure that device manufacturers adhere to minimum, mutually intelligible IoT cybersecurity standards

Brazil defined a National IoT plan, to place the country in the forefront of IoT in the coming years, by modernizing the provision of public and private services, developing skills and entrepreneurship, as well as fostering innovation. The country also signed an IoT cooperation agreement with European Alliance for Internet of Things[25]. Both regions shall consolidate the joint-cooperation in this area.

RECOMMENDATION

Adopt IoT technologies and promote its adoption in EU & Brazilian societies, especially industry from across different sectors, while defining standardization and regulation protocols.

3.4 Challenges & Recommendations for HPC

3.4.1 HPC as market innovation enabler in Cloud Environments

High Performance Computing (HPC) allows the analysis of complex phenomena, in the areas of Life Sciences, Physics, Climate research, Engineering and many others. **HPC helps policy makers to make better decisions and enables industry to launch innovative products and services**: Cars, aircraft, engines and pharmaceuticals are all designed with the help of HPC. **HPC can provide a high Return on Investment for businesses**, being an indispensable for its competitive advantage. High Performance Computing (HPC) has been responsible for some of the most important scientific and technological advances in the last decades, requiring specialized Hardware and Software infrastructures, such as Clusters and Grids. The aggregated computational power of thousand processing cores of a conventional Cloud HW/SW infrastructure can be directly used for some HPC applications, however, for many parallel applications, the conventional Cloud's HW/SW limits the application performance scalability.

Neither Brazil and EU are in the Top10 of with PFlops supercomputers[26]. Neither Europe and Brazil appear in the top 10 countries. China & US combined have 65% of world's total computing capacity. In Europe there are some HPC initiatives, including PRACE, and an investment

[25] Source : http://www.brazilgovnews.gov.br/news/2017/03/brazil-eu-partnership-will-focus-on-internet-of-things-and-5g
[26] Source : https://www.top500.org/lists/2017/06/

announcement of 486 million Euros between 2018 and 2028. In Brazil, HPC efforts are mainly in academic areas, including SINAPAD, a Brazilian government initiative to provide HPC services to the academic community. **Europe and Brazil shall collaborate to develop a powerful common HPC strategy, to increase innovation across sectors.**

Most of the computing devices have multiple processing cores, the number of cores per device will grow to dozens and hundreds, which will enable the execution of more complex applications at the same time. However, balancing the load imposed by these applications over dozens or hundreds of cores is not trivial. Nowadays businesses and enterprises produce massive amounts of data, thus, requiring HPC technologies plus AI to process and transform this data into valuable information.

Some challenges in this area are the design and delivery of new Hardware and Software techniques, mainly in parallel process communication, scheduling and synchronization, in order to overlap the limitations imposed to performance applications running on Cloud infrastructures. Also, it is important to consider the design and delivery of cloud-based communication protocols focused on decreasing the communication delay among HW/SW infrastructures and improve the work loading among the HPC architecture. Another important topic is the design of prediction models and performance evaluations models to monitor and improve operation in cloud-based many-core systems as well as the design and development of Artificial Intelligence–based services on data derived models supported by cloud computing and HPC developments to achieve desired levels of efficiency to resolve most complex problems.

RECOMMENDATION

Invest in HPC to solve societal problems in areas of life science, physics, climate & engineering, amongst others, for business development and improve society life quality

3.5 Challenges & Recommendations for 5G & other networks

3.5.1 5G Architecture for Vertical Markets

5G is also a technology that can support the creation of generic IoT based systems**. 5G is not just a network but a platform for wireless communication integrating various technologies which make the execution of IoT possible**. The advanced properties of a 5G network are particularly pressing for applications and devices related to IoT. 5G networks will meet the requirements of a highly mobile and fully connected society. The proliferation of connected objects and devices will pave the way to a wide range of new services and associated business models enabling automation in various industry sectors and vertical markets (for example energy, e-health, smart city, connected cars, industrial manufacturing, etc.). Also, the 5G networks will support the communication needs of machine-to-machine and machine-to-human type applications.

Autonomously communicating devices will create mobile traffic with significantly different characteristics than today's dominantly human-to-human traffic.

Through the interaction with the community of the industry verticals, a number of use cases have been defined as variations of a small set of basic 5G service classes, which have been consolidated and agreed in the context of 5GPPP and different SDOs as follows: Enhanced Mobile Broadband (eMBB), also called Extreme Mobile Broadband; Ultra-Reliable and Low Latency Communications (URLLC), and Massive Machine Type Communications (mMTC). Additional use cases certainly will emerge and are not foreseen today. For future 5G systems, flexibility is necessary to adapt to new use cases with a wide range of requirements.

The industry consensus is that by 2020, 5G network of the future will involve the integration of several cross-domain networks, and the 5G systems will be built to enable logical network slices across multiple domains and technologies to create service-specific networks. The network slicing shall realize end-to-end (E2E) vision starting from the mobile edge, continuing through the mobile transport until the core network. This will enable operators to provide networks on an as-a-service basis and meet the wide range of use cases that the 2020 timeframe will demand. In the same context, a profound relationship is considered between the concept of network slices and 5G integrated environments.

The network slice is a composition of adequately configured network functions, network applications, and the underlying cloud infrastructure that are bundled together to meet the requirements of a specific use case. An infrastructure provider will assign the required resources for a network slice, that in turn realizes each service of a service provider. Hence, a network slice comprises a subset of virtual network infrastructure resources and the logical mobile network instance with the associated functions using these resources. The focus of the architecture includes the softwarization of 5G systems allowing efficient management and orchestration procedures providing a flexible sliced service platform for different types of service verticals running on a common infrastructure.

RECOMMENDATION

Support the the definition of a 5G architecture based on network slicing to support vertical markets and service specific networks on a common infastructure

3.6 Challenges & Recommendations for joint International Collaboration & Presence

3.6.1 Sustainability of EU-BR funded projects

The resulting coordination calls, which began in 2010, have already produced some practical results. Today four calls in ICT have been launched, with 20 projects receiving funding for innovation in relevant key topics for both regions.

It is crucial that **EU-BR projects demonstrate the concrete/real impacts of such cooperation in European and Brazilian societies**. It is fundamental to take up research results, bring innovation to the market, and to create new jobs and business concepts, among other activities. How can technology improve Brazilian and European living conditions? The mindset is not the technology itself, but how we can make the world a better place by using technology[27].

Future EU-BR projects must demonstrate the real impact on society and how they will contribute to the development of the digital economy between both regions. However, **how can the sustainability & success of these projects be improved?**

Involve the end-users, right from the beginning, and even from the proposal writing. Taking into consideration end-users needs will ensure a more effective exploitation/sustainability. It is also **important to have pilots, with real users, instead of simply having demos**. Provisions must be made to guarantee that the involvement of users in pilots is real. Plus, **projects shall organise joint-events** (e.g. workshops), **to share results, expertise and lessons learnt**, while promoting the reuse of solutions between the projects.

Future EU-BR consortia should have a **better balance of Industry representatives, not exclusively from ICT**. The involvement of industry is a key to ensure the sustainability of assets beyond the end of funding. Projects shall include "Go to Market" strategies mandatory as part of the implementation plan, at least 15 months before project conclusion, so that an exploitation plan is delivered earlier, to ensure sustainability of the project after the end of the funding period.

Project sustainability shall not focus only in maintaining components, but also in making these components an integral part of future research and listing them in the work programme call description text, to bring more added value for future tools and services. The EU-BR projects shall integrate assets from past projects.

Future EU-BR calls shall not have only RIA (Research and Innovation Action) projects but also CSA (Coordination Support of Action). EUBrasilCloudFORUM was indicated as an CSA to support the promotion of EU-BR projects. Having a dedicated project focused on this topic, to maintain EU-BR collaboration in ICT should exist.

RECOMMENDATION

Involve end-users & industry in research consortia, create real use-cases, define go-to-market strategies, use assets from previous projects, ensure real & meaningful impact in EU-BR societies, organise networking events and share expertise, to increase EU-BR projects sustainability.

[27] Source: https://www.atmosphere-eubrazil.eu/cloudscape-brazil-and-wcn-2018-event-report

3.6.2 EU-BR as a worldwide player in ICT

In our modern area, the most valuable companies that now hold the top places in stock exchange markets are all technological organisations (e.g. Google, Apple, Amazon, Microsoft), based in a few non-European & Brazilian key countries, dealing with large amounts of digital data. **It is without doubt that "data" is the gold mine of the world's 4th industrial revolution and unquestionably an economical asset.** In this digital revolution, data is treated as a new type of economic asset, which is rapidly becoming vital in the global economy.

Ranking of the companies rank 1 to 100	Market value in billion U.S. dollars
Apple	926.9
Amazon.com	777.8
Alphabet	766.4
Microsoft	750.6
Facebook	541.5
Alibaba	499.4
Berkshire Hathaway	491.9
Tencent Holdings	491.3

Figure 4 Largest companies in the world by market value[1]

According to Carlos Oliveira, Counsellor for Information Society and Digital Market at the EU Delegation in Brazil, believes that **businesses shall become more digital & increase the innovation capacity in distinct industry areas**: energy, health, biodiversity, agriculture, crisis management, education, transport, amongst others. **EU and Brazil shall exploit the potential of ICT as an enable of innovation across sectors.**

To compete with these "giants" of technological innovation, Europe and Brazil shall also create economies of scale. **Europe and Brazil shall become one actor defining new market paradigms, with the same power as these "giant IT companies",** as opposed to a simple passive adopter. The two regions shall become a joint and single player and develop more innovative technologies that will not only improve the competitiveness of the two regions, but **also lead the digital economy and transformation around the world.** A strong transatlantic digital market requires strong and worldwide recognize ICT players.

RECOMMENDATION

Digitise the EU-BR market and get value from data, by investing in complementary digital technologies (IoT, Cloud, Data Analytics, Artificial Intelligence)

3.6.3 EU-BR international collaboration

The international cooperation between European and Brazilian institutions, creating a base of contacts for future collaboration, even not related to EU-BR calls, represent a valuable return-of-investment. International collaboration is a crucial pillar to address world-wide challenges and stablish innovative synergies that will have impact in both EU and Brazilian societies.

SMEs shall have an important role on this international collaboration, since they are the life-blood of both the EU and Brazilian economies. However, Europe and Brazil are geographically

far away, being hard for SMEs from both sides to do business with their counterparts[28]. It is important to support SME from EU and Brazil can gain **easier access to the counterpart market and establish cooperation between SMEs from these 2 regions**.

EUBrasilCloudFORUM marketplace[29]'s goal is to support this. It is an online meeting point where all those interested in promoting collaborative initiatives in ICT, can find relevant information from past and current research initiatives, get in touch with key stakeholders, and access tangible technological assets produced in both regions.

RECOMMENDATION

Support SMEs to increase international visibility, trought EU-BR marketplace, networking events and other mechanisms

Brazilian and European cooperation has been impressive, with results that can have a real impact in both regions' societies, namely the creation of the Special Interest Group (SIG) in Cloud Computing, within the SBC. The SIG in Cloud Computing is a great opportunity to increase collaboration between academia and industry, and it is important to recruit new members at the earliest, so they can start discussing topics and priorities for the field. Members can be Brazilian & European academic experts, motivated on structuring the evolution of the area within the research community in Brazil for the upcoming years.

Besides SIG, Coordination Support Actions (CSA) projects support research actions and strategies, such as networking and exchange actions, cross-border access to research infrastructure, studies, conferences, preparation of studies, amongst others. Having a CSA project to support not only the work carried out by the research projects but also the increment of international collaboration between both regions, will contribute to a joint-market development.

RECOMMENDATION

Support/create Special Interest Groups and Coordination Support Actions in ICT to support international research work, policy discussions and networking

3.7 International Standards & Legislation

3.7.1 FAIR Data: Findable, Accessible, Interoperable and Reusable

Data sharing benefits not only researchers but also society in general**. Sharing data today enables new science & services tomorrow**[30]. When shared, it contributes to big data and fuel

[28] Source : http://www.czechstartups.org/en/business-opportunities-for-european-smes-in-brazil/
[29] Website : https://www.eubrasilcloudforum.eu/en/marketplace
[30] Source: https://www.nature.com/articles/s41467-018-05227-z

future scientific discoveries in unexpected ways. A major function of data sharing is the reuse of data for purposes other than those intended by the people who collected the data.

Data reuse requires both standards and a level of rigor and semantic specificity enough not just for human, but also for computational analysis. There is a pressing need to create standards to ensure that shared data can be pooled and compared. Standardization also provides opportunities for additional impact on clinical research through increased data quality, better data integration and reusability, facilitation of data exchange and communication with partners, interoperability of software tools, and facilitation of regulatory reviews and audits[31].

As an example, the **health market is a sector that will develop greatly with data sharing**. In Europe, the e-Health Market was worth $25.50 billion in 2016 and is estimated to be growing at a CAGR of 15.60%, predicted to reach $52.65 billion by 2021[32]. There is an increase in the prevalence of chronic diseases, frequently co-occurring, which requires the simultaneous coordination of several health care professionals. To ensure that they have all the patient's health information **it is important to keep individual health care under observation in an integrated way, which includes extracting large amounts of health data from different sources**, (Marcia Ito, from at IBM Research Brazil. It is **crucial that all these data are integrated and interoperable via IoT and other technologies, to improve the flow of information and, therefore, expand the access to health care and qualify care teams**[33]. Wim Degrave, Researcher at *Fundação Oswaldo Cruz*, mentions that there will be **high number of data repositories, which will have required standards for data structure and data exchange, to take the most out of this valuable info**.

There is no standardized way to represent the data and metadata between the two regions, which substantially limits the applicability of new solutions, especially for innovative SMEs. Standards will be needed for supporting reliable system communication and integration, including for managing security and privacy aspects of big data in the cloud. This leads to the need to create a self-sustainable community on standards, and address the actual concerns on the adoption of standards by industry, to avoid vendor lock-in. This includes standards for data representation, and for enforcing application developers to handle personal data adequately, while allowing people to define fine-grained access control policies to their data. Also, it is important to consider the development of a legal framework to facilitate policy dialogues between EU and Brazil program managers, researchers, and industries and to develop guidelines for helping preparation and submission of novel standards for cloud computing, including privacy and security. Finally, another important action is the definition of standards and best practices towards a security platform that ensures data confidentiality, data integrity, and data access auditability.

[31] Source: https://www.nap.edu/read/18267/chapter/6#45
[32] Source: : https://www.marketdataforecast.com/market-reports/europe-e-Health-market-1237/
[33] Source: https://www.atmosphere-eubrazil.eu/cloudscape-brazil-and-wcn-2018-event-report

All in all, Data shall be FAIR[34]: Findable, Accessible, Interoperable and Reusable. The FAIR principles specifically emphasize enhancing the ability of machines to automatically find and use data or any digital object and support its reuse by individuals. Standards for the description, interoperability, citation etc. are at the core of these principles.

RECOMMENDATION

Support the definition of international standards, for the benefit of data sharing, data integration and data interoperability, across sectors and borders

3.7.2 Legislation for Data Protection legislation to control data usage

It is difficult to maintain control of personal information that instantaneously populates the online environment. This is where data protection comes in. **Strong and effective data protection law is a necessary safeguard against industry and governments' quest to exploit our data.** In 2016, 57% of consumers worldwide reported that they were more concerned about their online privacy than they were in 2014[35]. **The data driven economy is emerging, as well as the use of data in governance**. To effectively do both, without causing considerable harm to individual privacy, **a strong international data protection law is needed**. A robust law will also **enable cross border data flows with other economies and enhance the capacity of local industry to provide data processing services globally**[36].

The **European General Data Protection Regulation (GDPR) is now the strongest data protection regime in the world**, leading many to hope that it will set a 'gold standard' for another jurisdiction. **Brazil recently approved "*Lei Geral de Proteção de Dados Pessoais*" (LGPD), highly inspired in GDPR**. Brazil approved a bill that comprehensively regulates data protection, coming into force in February 2020. The LGPD is very similar to the GDPR in context, structure and ultimate rational — to protect the fundamental rights and freedoms of natural persons, especially the development of natural persons' personality. Having similar Data Protection framework simplifies international data transfers and ensure long-lasting data protection solutions.

However, GDPR comes with many challenges to cloud providers, like effective data retention implementation, processing of personal data outside the European Economic Area (EEA), data portability for the controller from the cloud, etc. These challenges must be anticipated when using cloud services, which requires Cloud architecture and privacy by design.

[34] Source : https://www.go-fair.org/fair-principles/
[35] Source: https://www.consumersinternational.org/media/155133/gdpr-briefing.pdf
[36] Source: https://medium.com/@privacyint/data-protection-across-the-world-fe66ca1e138f

Having a harmony on international laws provides consistency, stability in the legal system and will facilitate economic relation between both regions. This provides more confidence to organisations from one region to another.

RECOMMENDATION

Have the mindset or creating common legislation, to provide more confidence and promote international relations

4 Recommendations for EU-Brazil cooperation in R&I

Below it is available a summary of all research & innovation opportunities/recommendations described in previous chapters. This summary has the mindset of implementing joint EU-BR research and innovation projects that will have a real impact and sustainable development on both regions' economies & societies. It is crucial that EU and Brazil have the same vision, to achieve global goals and harmonize processes, technologies, industries and, ultimately, their societies. This is a preliminary set of recommendations that will analysed and updated and improved in the next 12 months of the project, using among others, the feedback of the engaged communities.

Policy Recommendations

- **Digitise the EU-BR Market**: get value from data by investing in complementary IT technologies (e.g. IoT, AI, Cloud) to enable digital innovation across sectors.
- **Exploit the potential of HPC**: define common HPC strategy, to increase market development and benefit from the potential of high volumes of data.
- **Support the creation of cyberinfrastructures for e-science**: The larger the investment on e-infrastructures for data-sharing, the greater the value that science and research can bring to market.
- **Increase Security and Trustworthiness on Cloud**: eliminate factors that are apprehending the adoption of cloud computing
- **Develop innovative approaches to create, configure and manage time varying edge clouds**, up to the case where each Internet connected device is a cloud provider/member, going beyond the fog paradigm.
- **Increase cyber-resiliency of companies, citizens and governments**: cyber-resilient players will increase and contribute to stable market developments.
- **Support the definition of a 5G architecture** based on network slicing to support vertical markets and service specific networks on a common infrastructure.
- **Develop smart manufacturing industry for higher levels of efficiency**: smart manufacturing, relied on IT multiple technologies, increases market opportunities across different sectors, while defining standardization and regulation protocols
- **Support SMEs & start-ups in achieving international visibility**: create conditions for each side access the counterpart market, through events, marketplace, funds and joining international consortiums, to increase the probability of finding new partnerships and clients for their services/products.
- **Define international standards for data sharing**: if data is easily shared, integrated and interoperable, across sectors, most of the conditions to take most out of the info are created.
- **Define common laws to control data usage**: The GDRP and LGPD will simplify international data transfer. Keep defining harmonize laws will ensure consistency and facilitate economic relation between Brazil and EU.

Europe-and Brazil Project Next Steps & Recommendations

- **Involve end-users & industry in research consortia**: taking into consideration end-users needs will ensure a more effective exploitation/sustainability. Industry is key to ensure sustainability of assets beyond the end of funding.
- **Require go-to-market strategies in future funded projects**: shall be mandatory the inclusion of an exploitation plan, to be implemented before project conclusion.
- **Create real use-cases**: guarantee the involvement of real users, to the market impact can start still during the project implementation and have a clear picture of what are users' needs.
- **Provide networking events**: joint-events (e.g. workshops, conferences) to share results, expertise and lessons learnt and connecting players that, without the support of these events, would not be able to network with their own resources.
- **Use assets from previous projects**: require the use of assets resulted from previous research projects in future ones, to ensure their sustainability.
- **Ensure that a CSA is active & support SIGs**: to guarantee that EU-BR cooperation has support from experts whose only goal is to reinforce the cooperation.
- **Ensure meaningful impact in EU-BR societies**: take up research results, bring innovation to the market, to create new jobs and business concepts, among other activities

5 Conclusions

This deliverable presents a Preliminary Research Priorities Report, that summarizes the EU Brazil joint effort initiatives in cloud computing and reports a preliminary analysis of the present challenges and joint EU Brazil research innovation opportunities.

The document presents an initial analysis that is based in the relevant initiatives in EU and BR in these fields in the last year, including stakeholder inputs and alignment with the EU Brazil policy dialogue with the purpose of linking research and innovation opportunities and challenges identified with industry firms of all sizes. This document may directly contribute to the next EU Brazil future policy dialogues in 2018 and 2019. The document also includes experiences and best practices on cloud computing related to a collection of services platforms, frameworks, software libraries, applications and federated container-based infrastructures.

The document is organized in five sections, which present the EU Brazil joint initiatives until today and describe the present challenges and opportunities for joint EU-Brazil research & innovation and discusses a set of initial recommendations for EU-Brazil cooperation.

The project intends to review, update and improve the priorities and recommendations in this document in the next twelve months, mainly supported by the tasks in Work Package 2 and Work Package 8. These updates will be described in deliverable D2.5 in month 24.

6 ANNEXES

Project	Nº call	Goals	Results (4th call Expected results)
Bemo-Cofra BEMO-COFRA	1st EU-BR call	Ensure confidentiality, integrity, consistency and availability of applications in the cloud. Develop an innovative distributed framework which allows networked monitoring and control of large-scale complex systems by integrating heterogeneous smart objects, legacy devices and sub-systems, possibly cooperating to support holistic management and achieve overall systems' efficiency with respect to energy and raw materials.	Manufacturing plant where dependability of the system is of the utmost importance and where a very large number of devices, systems and WSAN devices interact and actively cooperate with each other to enable a very accurate observation of production processes
SecFuNet SecFuNet	1st EU-BR call	Design and develop a coherent security architecture for virtual networks and cloud accesses	A Virtual Network Isolation, Automatic Migration to Save Energy, Scalable Intrusion Detection & Prevention System, Content Centric, Network Experimentation.
EUBra-BIGSEA EUBRA BIGSEA	3rd EU-BR call	To create a sustainable international EU-BR cooperation activity in cloud services for Big Data analytics.	An efficient Big Data Analytics platform supported by self-adaptable cloud services, real use case implemented on the platform for data analysis from massively connected societies & liaison an International Research Community on Cloud & Big Data
SecureCloud SecureCloud	3rd EU-BR call	Ensure confidentiality, integrity, consistency and availability of applications in the cloud, focusing on: 1) Technologies for secure computation, 2) Cloud Services for IaaS and PaaS, 3) Smart Grid applications, 4) QoS for stream processing applications	New service options for cloud computing users , namely novel applications that rely on highly sensitive data and Software for managing secure containers in the most used platform for cloud computing
ATMOSPHERE ATMOSPHERE	4th EU-BR call	Provide a solution to assess trustworthiness of cloud applications dealing with data and support the development of more trustworthy cloud applications	Trustworthy Data Processing Services & Cloud services managing federated and hybrid resources – performance prediction service and proactive rules
NECOS necos	4th EU-BR call	Solve the limitations of current cloud computing infrastructures to respond to the demand of new services	Novel solution based on resource virtualization as an approach for automating the process of optimal cloud configuration by extending the virtualization concept to all resources in a data centre.

Table 3 EU-BR funded projects on cloud computing

Project	Nº call	Goals	Results (4th call Expected results)
FIBRE Testbed	1st EU-BR call	Prepare the next generation of researchers to deal with the challenges of evolving the current Internet, by providing a largescale platform to promote Future Internet research in Brazil and the region.	Platform for experimentation and education on computer networks, built on top of FIBRE's project legacy infrastructure and operated as a service for the academic community.
EUBrazilOpenBio	1st EU-BR call	Drive forward the interoperation of existing Brazilian and European e-Infrastructures in the distributed computing, scientific data and portals & platform layers	EUBrazilOpenBio gateway: access point to a number of resources, serving the needs of biodiversity scientists involved in the development and alignment of species taxonomies and in the modelling and projection of ecological niche models to predict and to understand the distribution of species.
EUBrazil CloudConnect	2nd EU-BR call	Foster EU-Brazil international cooperation in distributed computing infrastructures at three levels: 1) Federated Cloud infrastructure; 2) Integrated Software development Platform 3) Applications for international collaboration	Platform for Cloud & Data Analytics Services, International collaboration, with interoperability of EU and Brazilian technology in Clouds.
BELLA	Other (H2020)	Provide for the long-term interconnectivity needs of European and Latin American research and education communities	Creation of the direct submarine cable between the two regions & complete the terrestrial optical fibre network infrastructure

Table 4 EU-BR funded projects on e-Infrastructures

Project	Nº call	Goals	Results (4th call Expected results)
PodiTrodi	1st EU-BR call	Create a single self-contained unit, with a human-machine interface, suitable for point-of-care diagnosis of the diseases (e.g Chagas), which integrates several technologies such as heterogeneous Microsystems (biosensors and microfluidics), control electronics, sensor read-out and an embedded processor and power supply.	Device controlled by a portable instrument including sensor read-out, human-machine interface and embedded processor, suitable for point- of-care diagnosis of Chagas' Disease.
FASTEN	4th EU-BR call	Develop, demonstrate, validate, and disseminate an integrated and modular framework for efficiently producing custom-designed products. Sophisticated software technologies for self-learning, self-optimizing, and advanced control will be applied to build a full connected additive manufacturing system	Support Industrial companies on overcoming challenges of this nature to cope with an increasing demand diversity, products with shorter life cycles, and the need for supplying low volumes per order, requiring flexible solutions capable to effectively manufacture and deliver personalized products.

Table 5 EU-BR funded projects on Microelectronics & Smart Manufacturing

Project	Nº call	Goals	Results
EUBrasil CloudFORUM	3rd EU-BR call	Facilitate the establishment of an organisational cooperation model that enables the EU and Brazil to formulate and develop a common strategy and approach for Research & Innovation in Cloud Computing in line with the priorities of each region	Final research roadmapfor the future of the EU/BR collaboration in cloud computing including security aspects.
ENRICH	Other (H2020)	Strengthening cooperation in research, innovation, and business between Brazil and Europe by exchanging innovative practices, experience, and knowledge between all parts involved	Become a main hub and contact point for European and Brazilian Science, Technology, and Innovation (STI) actors aiming at bilateral cooperation, as soon as 2021
INCOBRA	Other (H2020)	Increase and enhance Research & Innovation (R&I) Cooperation Activities between Brazil and European Union R&I actors, so that both regions get the best value out of the mutual cooperation	Increased cooperation patterns based on new or existing networks, supported in their development and expansion.
EURAXESS	EU Initiative	Links researcher in Brazil and other Latin America and Caribbean countries with Europe.	-

Table 6 Other EU-BR initiatives