Towards a Human-Centred Cloud Computing:
an International Perspective on the Public Interest

Position paper of the IFIP-DCCC (Domain Committee on Cloud Computing)

Abstract

This paper presents the work undertaken by IFIP's DCCC point of view on Cloud Computing. The work of the DCCC is described at the very end of the paper. Cloud Computing is one of the main paradigm shifts in the history of computing and information processing. This position paper analyses the several impacts on companies (SMEs and large enterprises), society (public authorities, users, the scientific community), and the possible implications for policy makers. The implications of Cloud Computing are then analysed from the sustainability and the environmental point of view, the possible connections at global scale, and the need for a human-centred view. Finally the importance of Cloud Computing from the IFIP perspective is discussed.

Introduction

This paper proposes a view of Cloud Computing as a new kind of socio-technical system. From the technical point of view, with Cloud Computing, Information and Communication Technologies (ICT) become *ICT-as-a-service*. While this development represents one of the main leaps in the evolution of computing, it also has many impacts from the social, organizational, and environmental point of views. Several organizational, infrastructure and societal implications follow.

For many organizations, in budgetary terms, moving ICT from the capital expenditure line to the operational expenditure line, by encouraging the use of ICT services "on-demand" and paying for them according to their consumption, is an opportunity that offers great flexibility and cost savings. For research infrastructures, specifically, when (big) data analysis is scaled up, "publicly run" clouds for scientific research provides a very attractive view.

Cloud Computing represents a big shift - back again - towards centralized architectures, where end-users and organizations consume on-demand resources provided by very large data-centres.

It is probable that, in terms of computer storage and processing power, the independence and "autonomy" introduced by the personal computer revolution in the 1980's, will be dramatically changed by the dependence and "heteronomy" introduced by Cloud Computing in the XXI century.

This paper proposes an analysis of the Cloud Computing phenomenon from several perspectives with the aim to provide useful instruments for policy makers, decision makers, and end-users who are considering entering the world of *ICT-as-a-service*.

1. Cloud Computing: a main paradigm shift in history of computing

The promise of Cloud Computing, is to have a global infrastructure with the following characteristics: it is *network-based*, it is based on computing servers that become shared-platforms (with resource pooling and *multi-tenancy*), it provides rapid *scalability* and elasticity (able to support dynamic demand for resources), it provides measured services (e.g. for "billing" purposes), and it is accessed on-demand, in many cases as a *self-service* (at the extreme it is possible to sign a contract online) (NIST, 2011, p.2).

Private Clouds

Of course many of these characteristics of Cloud Computing can be implemented *inside* an organization, provided it has a robust network infrastructure. This is the natural evolution of the "*intranets*" of the 1990's, where the data flows only behind the firewall of the organization and does not need to cross the public Internet. In these case, where all the traffic is under the strict control of the organization, the term "Private Cloud" is used. For many large organization this is the opportunity of consolidate large collection of servers (at the extreme, one server - one application) into a few big servers (consolidation) able to emulate many application environments and different operating systems (virtualization). Usually these applications are then delivered to the internal employees as "web services", via a simple browser and accessible also from mobile devices.

A Private Cloud is just a different way to implement the independence and "autonomy" of the organization from the ICT point of view.

Public Clouds

For many Small and Medium Enterprises or organizations (let us use SME for both) a private cloud is too expensive, so they rely on "Public Clouds" managed by the cloud providers, that is, external organizations that sell *ICT-as-a-service*. For SMEs this scenario is a real opportunity. They are enabled to access software applications from remote (Software as a Service, SaaS), development environments (Platform as a Service, PaaS) and ICT resources online (Infrastructure as a Service, IaaS). And they can access (and pay for) these services only when needed. In extreme cases, they need no more a computer room with servers (so avoiding procurement, servers' administration, and maintenance). They can concentrate on their business processes and, in most of the cases, the role of the CIO (Chief Information Officer) will change. This is also the trigger for big organizational changes. For example: will the line-of-business be authorized to select their own Cloud Services without the involvement of the CIO? Probably then the organizational and governance risks are too high and CIOs need to redefine their role from technical level to more strategic level. CIO and ICT personnel will need new skills, for managing ICT governance and for acting like partners of lines-of-business. Of course the delegation of ICT infrastructure to cloud providers does not

mean the complete delegation of governance: cloud computing cannot avoid the accountability of CIOs for organizations' information assets. As a result, for many enterprises, Cloud Computing will not be a replacement for ICT department, but it will redefine all the ICT governance.
In extreme cases, in particular for small organizations, there will be no more an internal ICT organization. The only requirements become: a broadband network and the user-devices (personal computers, smart-phones, tablets, etc.). The employees of these SMEs will just browse and access resources "in-the-cloud". All the ICT services will be provided from "outside", by a cloud provider. Of course here the data traffic have to cross the public Internet and the SME control domain finishes at the network point of access. Beyond it, the data crosses an (undefined) number of routers, controlled by other organizations, typically several Telco's (Cerf and Kahn, 1974, pp. 637-648) for reaching the data-centre of the Cloud Provider: it is the "Public Cloud".
From the business point of view this is an opportunity: moving ICT from the capital expenditure line (CapEx, necessary for installing, maintaining, and managing the company's ICT infrastructure), to the operational expenditure line (OpEx, a *service* paid on consumption), is very attractive. Think about high-tech start-ups from a university' incubator, that need to quickly access large storage and processing resources just for few weeks, for simulating some complex mathematical models. Public Cloud providers can offer them the solution: a virtually unlimited storage and computing power capability, on demand (Creeger, 2009). Think about a SME that needs to provide to its employees a simple customers relationship management application: with just a browser on their tablets they can start working immediately by accessing a SaaS solution (Howarth, 2011).
Nevertheless it is clear the shift in the control of ICT, a Public Cloud is a move towards an implementation of a kind of dependence and "heteronomy" from the ICT point of view.

Cloud Computing emerging issues
If we concentrate our attention on Public Cloud solutions, we can easily realize that this is a dramatic shift towards *centralized* architectures where cloud users use ICT service provided by very large data-centres controlled by cloud providers.
The Public Cloud scenario is moving from the peer-to-peer, many-to-many architecture of the historical Internet (Hafner, 1998) to a centralized "broadcasting", one-to-many architecture. The dependence from the network and from the cloud provider is evident. In some extreme cases, the "centre of the cloud" could even activate a kind of "kill switch" to "shutdown" machines and operating systems in the hands of the users (Karim et al., 2014).
The independence and the status of *digital citizens* provided by the distributed and personal computing of the 1980's risk to be lost as we become just *digital consumers* (ACMA, 2013, p.9).
From one side, (public) Cloud Computing is very attractive, but on the other side, it

is introducing a delegation of ICT infrastructure. Let us analyse some of the emerging issues in this direction:

- *ICT governance*
- *organization de-perimeterisation*

for the cloud user (organization) the borders will disappear, data and processing move outside, in the cloud, and inside, they will keep just input, output, and the network (see fig.1);

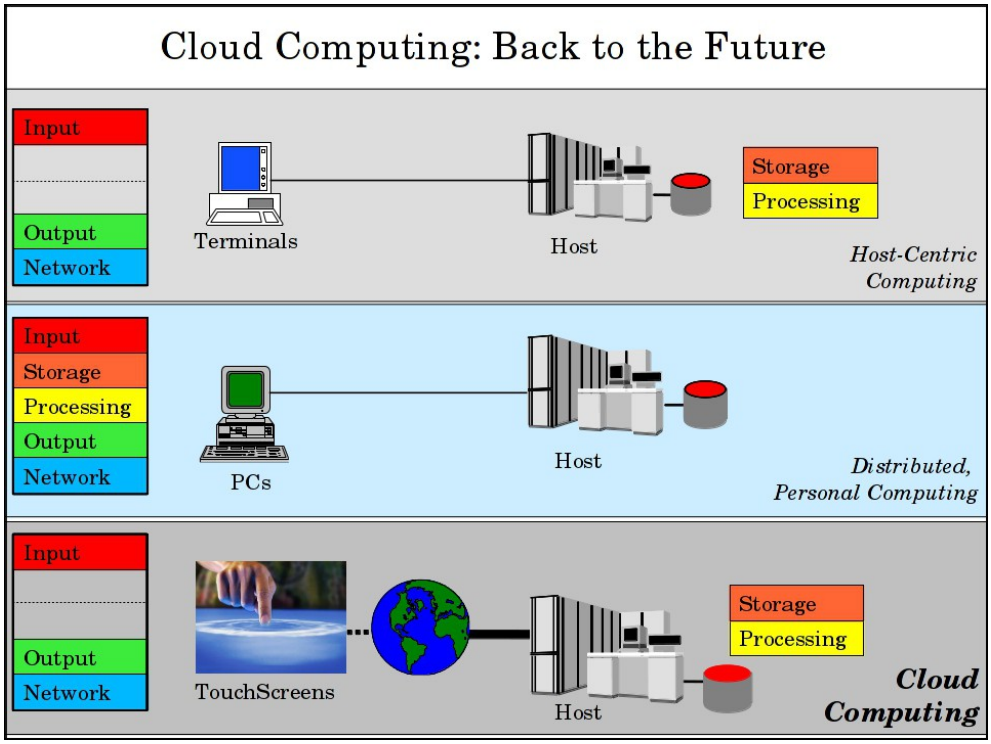

fig.1

- *contractual obligations (cloud brokers)*

if it is so easy to buy ICT resources, there will be organizations that will buy resources just for re-selling them: ICT "brokers". The cloud provider will not be the real owner of the ICT resources that it sells, it is just an intermediary (Schiering and Kretschmer, 2011, pp. 88-101); the chain of domains of responsibility becomes complex and also the contractual obligations have to be carefully defined. Maybe that some "cloud brokers" will have to start exposing some kind of "code of ethics" in front of their customers. It will be important to seek clarity on limitations of liability in contracts including exclusions of indirect, special and consequential loss, direct losses and disclaimers and warranties. Not all cloud services are created equal and not all cloud services should be subject to the same terms. A good

recommendation can be to undertake due diligence to fully understand the risks associated with cloud computing, and to adopt a risk-mitigation approach to cloud adoption. Service agreements need to specify those areas the cloud provider is responsible for: it will be needed to read the fine print of the contract carefully;
- *problem of many-hands*
it will be needed a kind of "*four-hands authorization*" mechanism (for some operations, the joint authorization of two administrators, one on the cloud provider side and one on the users side, will be needed), for all critical operations on the infrastructure there must be a forewarn mechanism between the cloud provider and the cloud user;
- *risk management*
the complexity of computer systems requires to all organizations to be prepared to reduce risks and to manage emergency situations: there will be the need to harmonize the risk-management plan of the cloud user with the risk-management plan of the cloud provider. Also, if something goes wrong it will be fundamental to have a trace of the events (*cloud traceability*), all events' meta-data (secure logs, *time-stamped* and *digitally signed*) have to be stored in some secure locations;
- *jurisdiction and compliance*
for the application of national laws and compliance requirements, cloud users will need to know the data location of their data, and which laws apply. It is important to note that the laws have a double role: from one side provide mandatory legal frameworks and on the other side provide contractual instruments to manage the relationships with providers (Juiz and De Pous, 2013);
- *information and data ownership issues*
in any scenario, governance and management have been changed. In governance frameworks, all ICT organizational layers (corporate governance, ICT governance, management and operation) are intervening in several decisions and controls related to cloud deployment (Juiz and De Pous, 2013). For example, in a SaaS scenario, all the ICT operational layers, including application, services, server, storage, and network, are delegated to cloud provider (Mether et al., 2009, p.30);
cloud users need to consider the issues of ownership of information stored on the cloud, and of intellectual property created using cloud technology. It will be wise to specify and define the ownership of "data" (including metadata) and related ownership rights;
- *data retention issues*
cloud users need to ensure that cloud provider's data retention and destruction policies comply with their requirements, as these requirements would depend on the nature of the activities and regulatory environment in which the user organization operates in. No single record retention requirements will be the same for different organizations;
- *privacy and security issues*
who is ultimately responsible for the protection of data/information that is stored and/or processed in the cloud? Management should maintain assurance that the

security of the cloud service provider is adequate for their purpose. Not all types of cloud services raise the same privacy and confidentiality risks. Risks vary with the terms of service and privacy policy established by the provider. Can cloud provider change the terms and policies at will? Do organizations have to comply with privacy legislation by restricting processing and transfer of data off-shore? Should agreements restrict services and data storage to agreed locations? Different levels of Data Privacy laws worldwide challenges trans-border dataflow across countries and lack of consistency in privacy laws worldwide makes monitoring compliance and assessing risk difficult and expensive. Whose privacy policy will apply at different stages of the data transfer? What security mechanisms are in place to manage data transfers between parties? What are the consequences of security and privacy breaches? How will users know if there is a breach? Are cloud service providers required to provide assistance in the investigation of security breaches? In these areas, a very important document related to cloud security and privacy issues has been recently published by the Council of European Professional Informatics Societies (CEPIS, 2011);

- *risk of lock-ins*

how can the cloud users avoid the risk of "monopolies" and lock-ins? What kind of standards will be available for data and application portability? This in one of the most critical issues for a company (Peng et al., 2014);

Addressing these issues is very important from cloud users and decision makers' point of view, and may require special attention when organizations define the cloud service contracts.

2. Cloud computing impacts

Several technical, social, and ethical issues raised by Cloud Computing are independent from the particular application and are due to the fundamental nature of this form of computing (Timmermans et al., 2010). Other issues, like security and privacy, are due to the immense power of collecting Big Data in the repositories of Cloud Computing providers (Pieters, 2011). In the following, this paper exposes the implications for the different stakeholders.

2.1. Companies (SMEs, Large Enterprises)

SMEs

As mentioned before, for a small company, the opportunity to have access to vast amount of storage and processing power is very attractive. Cloud Computing can really provide an acceleration of SMEs development. On the other hand all issues related to security and privacy apply. For a business it will be important also to underline the dependability of the cloud provider infrastructure, servers, databases, etc. in particular when a business trust the provider up to a point that

delegates to it sensitive data (Patrignani et al., 2015). As a consequence, it is very likely that many cloud providers will provide also improved security, like data encryption services.

Large Enterprises
Many large enterprises traditionally have an internal ICT department, a Chief Information Officer, etc. that manage all their ICT infrastructure. Cloud Computing, with the offering of shifting these costs from CAPEX to OPEX is very attractive. Anyway many of these organizations are applying internally the same paradigm of the cloud: they build their private clouds. It is very unlikely that large enterprises will delegate an external provider to manage all their storage and processing capability. The risks related to data loss and leaks, and to function creep of their data are too high. Nevertheless many of them are designing a mix of choices where mission critical data and applications (like customers data, financial data, transactions, etc.) are retained internally, while non-mission critical data and applications (like collaboration platforms, etc.) are purchased from cloud providers. These are the typical *Hybrid-Cloud* solutions (Lakshminarayanan, 2015).

2.2. Society (Public Authorities, Users, Scientific Community)

Public Authorities
The current financial climate induces in many governments and public authority ICT organizations a careful scrutiny of their ICT budgets. With cloud computing many local small data-centres can be consolidated in one single "regional" data-centre delivering cloud computing services to local public agencies. On the other hand it is too risky for a public entity to delegate to an external body the management of citizen data and applications that could be also sensitive for national security. According to a recent report of the European Network and Information Security Agency, public administrations need "*community cloud*" infrastructures for security and resilience reasons. A "community cloud" is a "private cloud" shared by sister organizations that have a secure and restricted access to this kind of cloud infrastructure and it is becoming more and more popular in many countries (ENISA, 2011). Many regional governments are providing this kind of secure "community clouds" to their local authorities reaching an optimal balance between costs savings and security. The technical infrastructure of the cloud also facilitates the reuse of software based on open source paradigm by several public agencies increasing the opportunities for cost savings. All Public Authorities should establish cloud policies for their ICT and public services (De Pous, 2012).

Users
Also for individuals the availability of many applications and data spaces in-the-

cloud is very attractive and their use is growing: 29% of US broadband users already have access to a cloud space and 90% of them are aware of this kind of opportunity (Dixon, 2014). For many users it is becoming familiar the notion of *using* resources instead of o*wning* resources: it is the dawning of the *sharing economy*. And Cloud Computing fits perfectly with this paradigm: use ICT-as-a-service instead of installing at your site storage and processing machinery. But is also true that, due to the security concerns, many cloud providers will have to offer improved security, like the ones based on strong-authentication (e.g. you know some password and you have some tokens in your hands). So the society will have to become more and more familiar with this kind of security levels. Also the users will have to be aware that their data will be collected in Big Data repositories for analytics, data mining and profiling applications.
From another side the wide uptake of mobile devices, including the fact that many employers push their employees to just use their private mobile device (the Bring-Your-Own-Device (BYOD) fashion), is driving the move to the cloud: every cloud application (SaaS) now provides a mobile access.
In this direction, many researchers are also investigating the social consequences of cloud computing adoption on large scale: the evolution of ICT has followed different paths induced by the historical contexts where they took place. The Socio-Technical Systems (STS) perspective suggested by many studies is very important for understanding the evolutionary path of ICT.
As Johnson wrote:
- the believe that technology develops independently from society is wrong;
- social factors steer engineers in certain directions and influence the design of technological devices and systems;
- on the other direction, technology shapes society, society and technology shape each other (co-shaping);
- adoption of a particular technology means adoption of a particular social order;
- systems are infused with social and moral values (Johnson, 2009).
If we take this STS view and then start looking at cloud computing as a Socio-Technical System, then several interesting questions arise: what kind of co-shaping are we witnessing between cloud computing and society? Why the society of the beginning of XXI century led ICT towards cloud computing? What kind of society will be shaped by this new direction of ICT? Will this new scenario introduce us into a very centralized society? (Patrignani and Kavathatzopoulos, 2013).
As already mentioned before, the risk of losing the status of "digital citizen" and becoming just "digital consumer" is growing.

Scientific Community
Inside the scientific community the debate about cloud computing is active since several years. In particular, computer professionals were one of the first categories to reflect on it. Also the social and ethical issues related to cloud computing have been recently addressed by several authors and some have underlined the new

social responsibilities in the hands of computer professionals: "... *IT professionals will be the engineers who will design, develop, and deploy the various technologies that will enable the cloud. So, it behoves us to be aware of both the opportunities and vulnerabilities that the cloud presents*" (Miller and Voas, 2010, p.2).
The scientific community is looking at cloud computing with interest since years, probably because at the core of cloud computing architecture there are often many of the technical solutions developed in the "grid" computing arena.
The cloud, with the promise of theoretically unlimited availability of computing power, can be an immense resource for scientific applications. Related researches can be the ones in High Performance Computing, Big Data, etc. In science there have already been experiences of shared ICT resources for complex tasks demanding non-conventional computing power: an example is the "grid-computing" paradigm where the distributed computing power can be used with applications specifically designed for these environment. In the new Cloud Computing scenario designing applications does not require anymore a specific design approach like in grid computing.
These scenarios with a description of all available computing resources can be a base for a global proposal, that **IFIP could support, like a *Global Computing Scientific Cloud*, an effort like the CERN in Physics based in Geneva**. All scientific communities of the world in needs of storage and computing power for scientific purposes could have access to this special cloud and, like CERN, all countries could contribute to this collection of computing facilities, a "***Cloud Computing for Science***" initiative, open to researchers from all over the world. This could represent a strong push for the evolution of cloud technology, and an opportunity for avoiding the commercial takeover of computational science.

4. The policy-makers' perspective

The cloud computing paradigm has been under the scrutiny of policy makers around the world in the last years. Many national authorities are encouraging their agencies to include cloud computing among the adopted solutions for their ICT services. The European Commission, for example, considers cloud computing with a central role in the European digital agenda and forecast positive impacts on private and public organizations: "... *private sector businesses using cloud computing report 10-20% lower IT costs, while cloud computing can also help the public sector improve efficiencies and lower costs...*" (European Commission, 2015). The same document estimates a cloud-related ICT market of about 80 Billions Euro by 2020. Most interesting are the proposals for the cloud evolution identified by the EU Commission: "... *to cut the jungle of different standards; ... to identify safe and fair contract terms and conditions; to establish a European Cloud Partnership with the participation of public authorities and industry*". The effective use of cloud computing by the Europe's public sector is the main goal.

On another front, also the ITU (International Telecommunication Union), the United Nations agency for ICT, established a focus group on cloud computing in 2010, with the goal "*... from the standardization point of view, to contribute with the telecommunication aspects ... security aspects of telecommunications, service requirements, etc. in order to support service / applications of cloud computing*" (ITU, 2010).
It is evident that cloud computing is definitely a direction encouraged by the public authorities around the world even if it also evident that coordination is required at policy and standardization levels.

5. The environmental perspective

Of course ICT use can optimise all the de-materialisation processes and reduce pollution. However, in the case of cloud, the power consumption of gigantic data centres of cloud providers should be carefully taken into account. For example, the energy used in powering ICT, including the cloud, is doubling every five years (Uddin and Rahman, 2010; Rowe et al., 2011), the more than three billions of users accessing the cloud need to power their devices, not to mention the energy consumed by the networks themselves (Narendra et al., 2014). A more focussed analysis of the environmental and sustainability aspects of cloud computing could contribute to improve, for example, the efficiency of the data centres:

"*... most data centres, by design, consume vast amounts of energy in an incongruously wasteful manner ... Online companies typically run their facilities at maximum capacity around the clock, whatever the demand. Data centres can waste 90% or more of the electricity they pull off the grid ... on average, they use only 6% to 12% of the electricity powering their servers to perform computations. The rest is essentially used to keep servers idling and ready in case of a surge in activity that could slow or crash their operations.*" (Glanz, 2012).

6. Possible Implications of cloud computing at global scale

One of the main challenges humanity is facing for the next decades is climate change due to the greenhouse effect. Considered as a whole, ICT's contribution to CO2 emissions is around the same level as that of the airline industry (Fettweis and Zimmermann, 2008; European Commission, 2012). So, reducing the impact of ICT can help society in facing the global challenge of climate change.
In one of the most complete studies done in this field, on the one hand, emissions due to ICT have been estimated to reach 1.25 gigatonnes of CO2 (GtCO2) by 2030. The impact is due to data-centres (28.8%), end-users devices (47.2%), and networks (24.0%). On the other hand, also by 2030, CO2 reduction induced by a wise use of ICT (functional optimization, dematerialization, in sectors like mobility,

manufacturing, agriculture, buildings, energy, etc.) could reach 12.08 GtCO2 (GESI, 2015).
While the balance looks positive, it would also be useful to take into account the CO2 emissions based on the manufacturing and development of ICT and those related to the growing problem of *e*-waste management, that is, it is vital to consider the entire life-cycle of ICT.
At global scale, it is important to analyse the consequences of the concentration of storage and computing power in certain countries and continents, on which the others countries become more and more dependent for their ICT services. Could this growing concentration of ICT power be part of a drive towards some kind of cultural imperialism and difficulties in dealing with diversity?

7. A Human-centred view of cloud computing

The cloud represents an interesting development also at human-scale.
The evolution in this direction has already been identified as offering big opportunities like the "always-on" capability, and the opportunity to access storage and processing power from anywhere. This "on-life" capability has also raised the issues of the existence of new limits, "*the self is the limit*" (De Wandre, 2014). The limits are those of: the human senses, the human capability to absorb the growing tsunami of bits, the human time scale; all these limits mean that cloud computing presents risks related to information overload. There are many researchers who now propose a new kind of ICT, like the good, clean, and fair ICT, implicit in the Slow Tech approach (Patrignani and Whitehouse, 2014).
On another front, in terms of individual human beings, the accumulation of personal data at a global scale in the Big Data repositories of the cloud introduces another dimension of risks for individual privacy, at a scale that will require international policies and norms to be established.
This preoccupation is increased by at least an order of magnitude when society begins to enter the so-called "Internet of Things": the collection of sensors that generates a continuous flow of information that needs to be stored and processed.
Another dimension of profound discussion will be opened up when people start wearing sensors on their bodies, with the extraordinary opportunities offered for "*in-vivo monitoring*" of ourselves - not just for sports but also for interesting *e*-health applications. Here human beings need to take seriously a human-centred approach so as to avoid the potential abuses / misuses of data about our blood, breath, glucose level, heart rate, temperature, transmitted via wireless body-area-networks to Cloud data-centres for BigData collection, analysis, and visualization.

8. IFIP and the Domain Committee on Cloud Computing

IFIP is the global professional federation of societies and associations for people working in Information and Communications Technologies and Sciences.

Established under the auspices of UNESCO in 1960 and recognised by the United Nations, IFIP represents ICT professional associations from more than 50 countries and regions with a total membership of over half a million. It also brings together more than 3,500 scientists and 13 Technical Committees to conduct research, develop standards and promote information sharing. Based in Austria, IFIP organises and supports over 100 conferences each year, fostering the distribution of research and knowledge to academics and industry practitioners alike.

Following a proposal by Forrest Lin from the Chinese Institute of Electronics, the establishment of an IFIP DCCC was approved by the IFIP General Assembly in September 2014. Its' aim is joining efforts from several IFIP's Technical Committees and Working Groups on the cross domain of Cloud Computing. This is to underline the importance of a cross-view of Cloud Computing with an "horizontal" approach spanning all IFIP TCs and WGs and of a development of a "human-centred" point of view of Cloud Computing, a cloud computing for the public interest, including its potential impact on public authorities, SMEs and society at large (such as the impact on science, when basic underlying techniques in science move from small data to BigData). This horizontal approach enables IFIP to speak as a single voice on this important topic and to establish specific collaborations on it with its' member societies and other international organizations such as ACM-SIGCAS (Association for Computing Machinery - Special Interest Group in Computers and Society) and IEEE (Institute of Electrical and Electronics Engineers).

As of June 2015 the persons who are participating in the IFIP DCCC are the following:

- Norberto Patrignani (chair, Italy)
- Dimiter Velev (vice-chair, Bulgaria)
- Yu Nenghai (vice-chair, China)
- Lucy Zhang (secretary, China)
- Victor De Pous (Netherlands)
- Allan Hanbury (Austria)
- Anthony Wong (Australia)
- Chrisantha Silva (Sri Lanka)
- Carlos Juiz (Spain)
- Emanouil Atanassov (Bulgaria)
- Forrest Lin (China)
- Henning Müller (Switzerland)
- Kai Rannenberg (Germany)
- Marko Hölbl (Slovenia)
- Nopasit Chakpitak (Thailand)
- Nick Tate (Australia)
- Vlado Stankovski (Slovenia)
- Yuko Murayama (Japan).

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