Challenges for Cloud Computing and beyond

Response to the Consultation
on
Cloud Computing
Research Innovation Challenges
for WP 2018-2020

November 2016

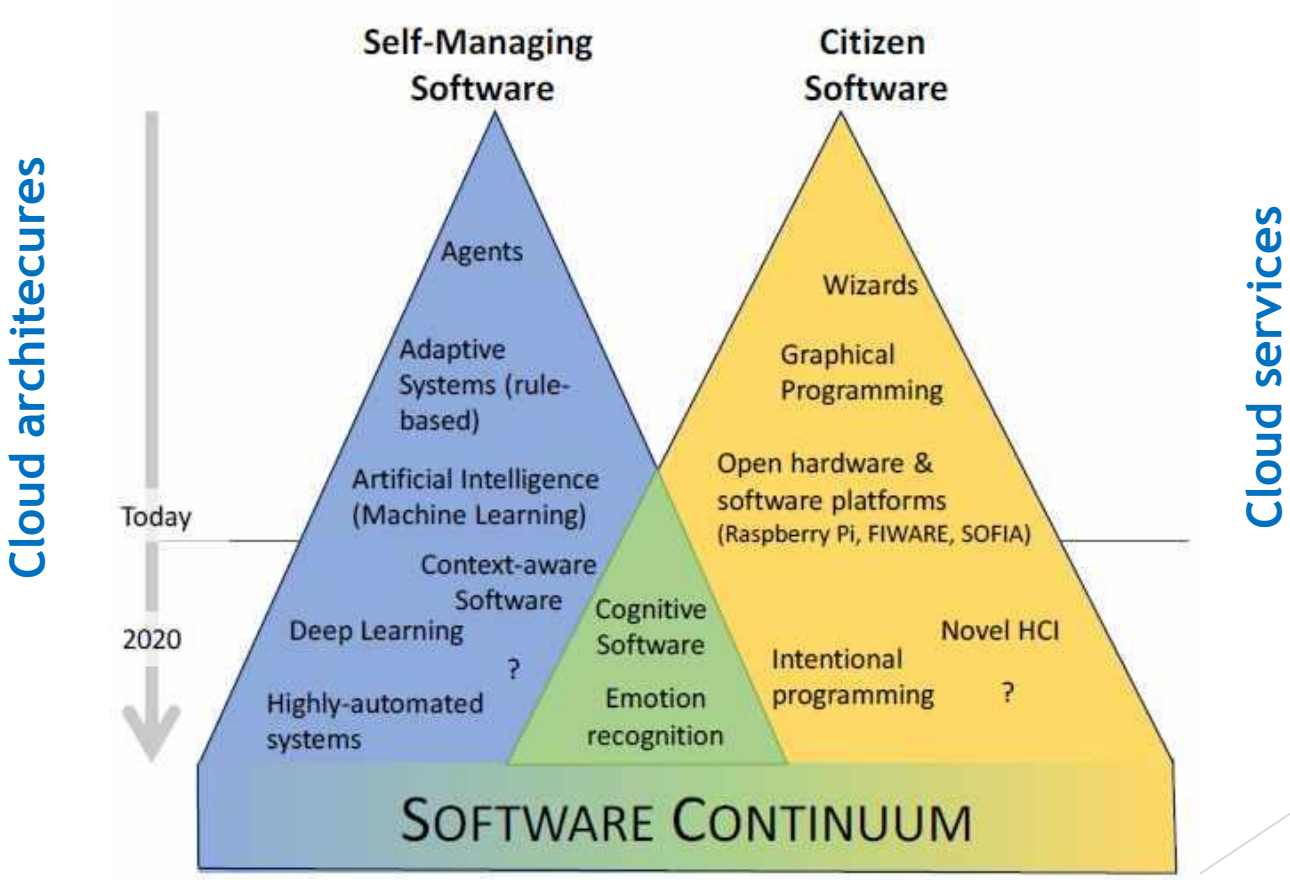
Cloud as part of a larger trend

- Cloud introduced 2 important paradigms in IT
  - Changes in the way the infrastructure ressources are managed, introducing new roles in the value chain and new processes in the development cycles of applications and services
  - Changes in the way the services are provided to the user, to answer the needs of an always connected world (anywhere, anytime, any device)

- It enabled new approaches to old problems
  - management of large scale systems (distributed world wide services)
  - simplification and automation of the deployment of applications (shortened time to market, better focus on business oriented function rather than infrastructure or technology)
  - new valorization opportunities for data and services

Cloud as part of a larger trend

- Along with big data, machine learning, open source, internet of things, it contributes to a new software continuum



Cloud : Challenges for infrastructure development

- Scaling while optimizing
  - management APIs, design patterns, automation
  - efficiency for performance and energetical impact
- Distributing while preserving behaviour and quality
  - middleware and frameworks for reliability and consistency
- Supporting heterogeneity
  - virtualisation, hybrid
- Hiding complexity
  - tools, APIs
- Compliance
  - privacy, security, sovereignty
  - SLA

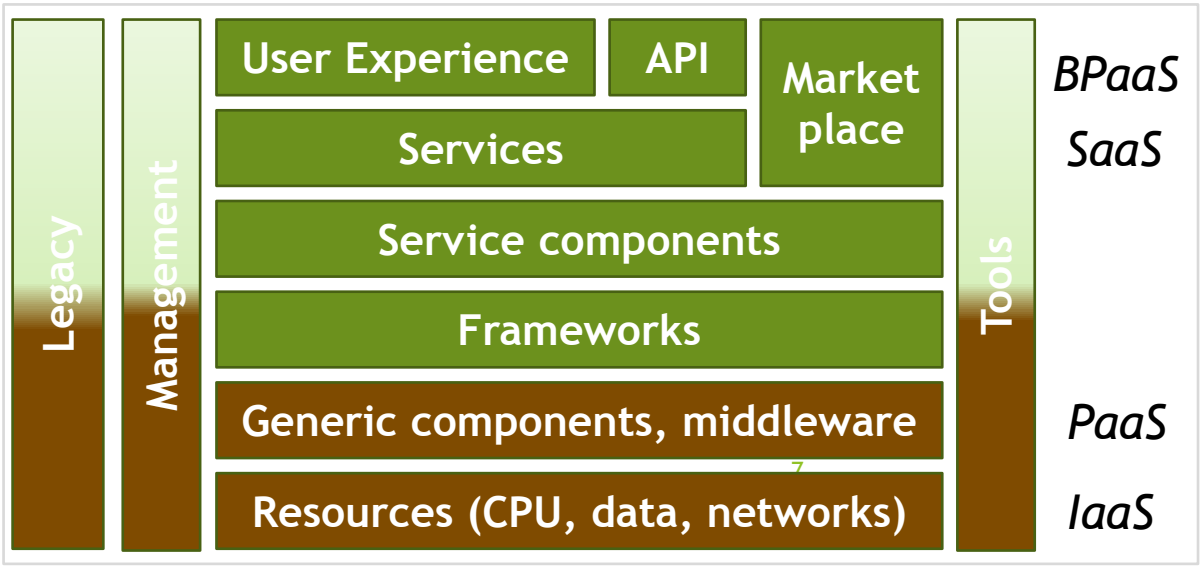
Cloud : challenges for application development

- Running short service life-cycles
  - devops processes, automated testing and deployment
- Embedding behaviour and experience in frameworks
  - business oriented architectures, cooperation of micro-services, embedded data analysis in applications
- Addressing all devices out there
  - device neutral API, consistency between device and cloud developments (« full stack »)
- Getting quality and security for free
  - supported by infrastructure, automation of validation
- Modernizing or digitalizing the legacy
  - reverse engineering tools
- Going to market
  - identity management, billing, market places

Previous NESSI priorities (2014)

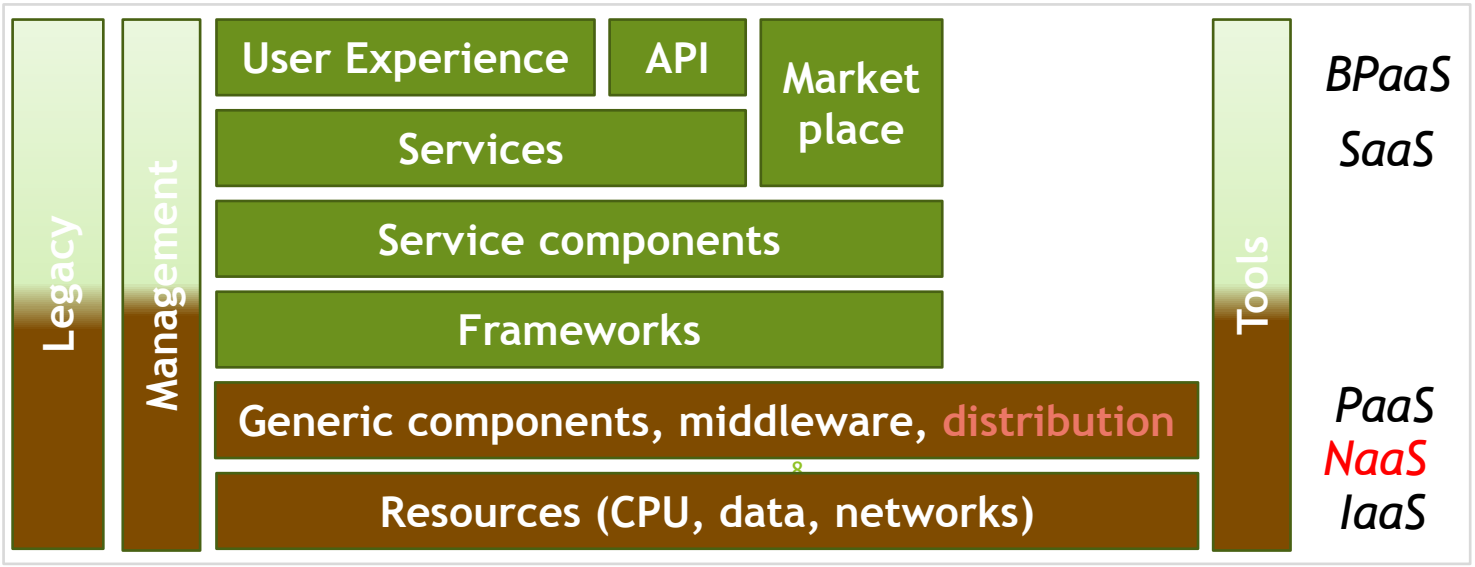
- Challenges
  - Federated cloud networking (from WP)
  - Automated service discovery and composition (from WP)
  - Cloud security (from WP)
  - Integration of the cloud and networks, IoT, CPS, mobile devices
  - Cloud for mission-critical large-scale systems
  - New programming models levegaring cloud infrastructures
  - Evolution of cloud architectures
- Non technical challenges
  - Standards and recommendations
  - Migration of legacy and adoption (SME, administrations)

Cloud cartography : 2014



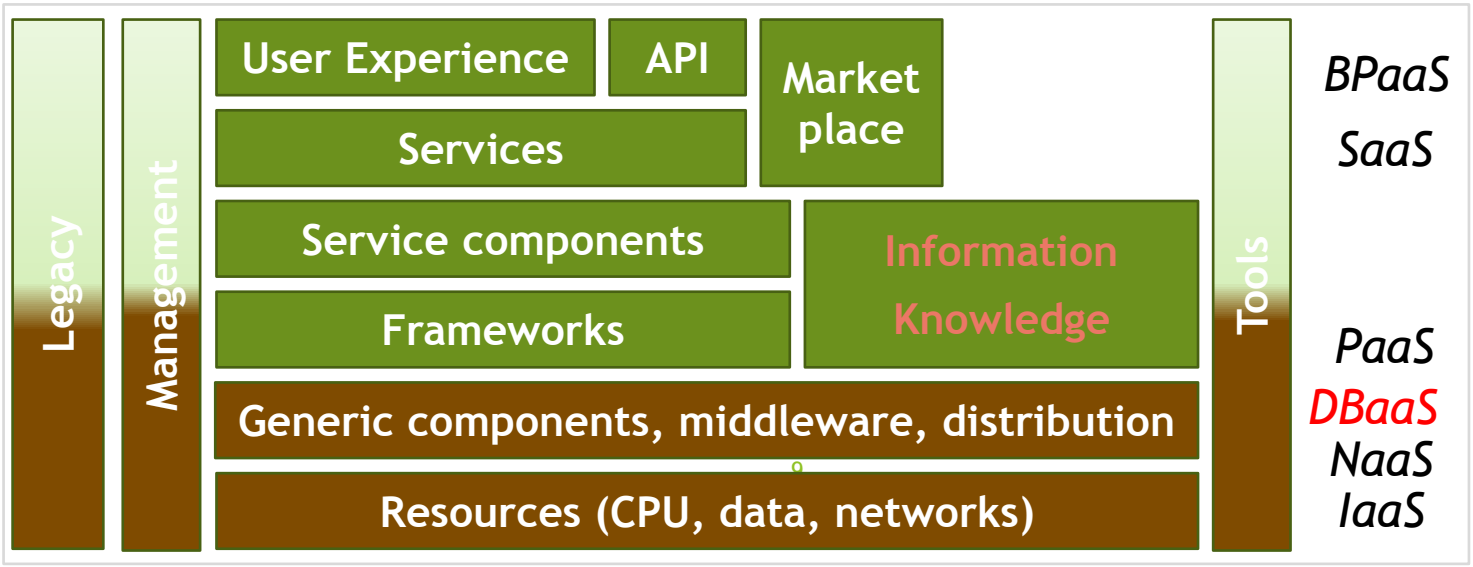
- Context
  - consolidation of infrastructures and API
  - open source solutions

Cloud cartography : 2016 and beyond



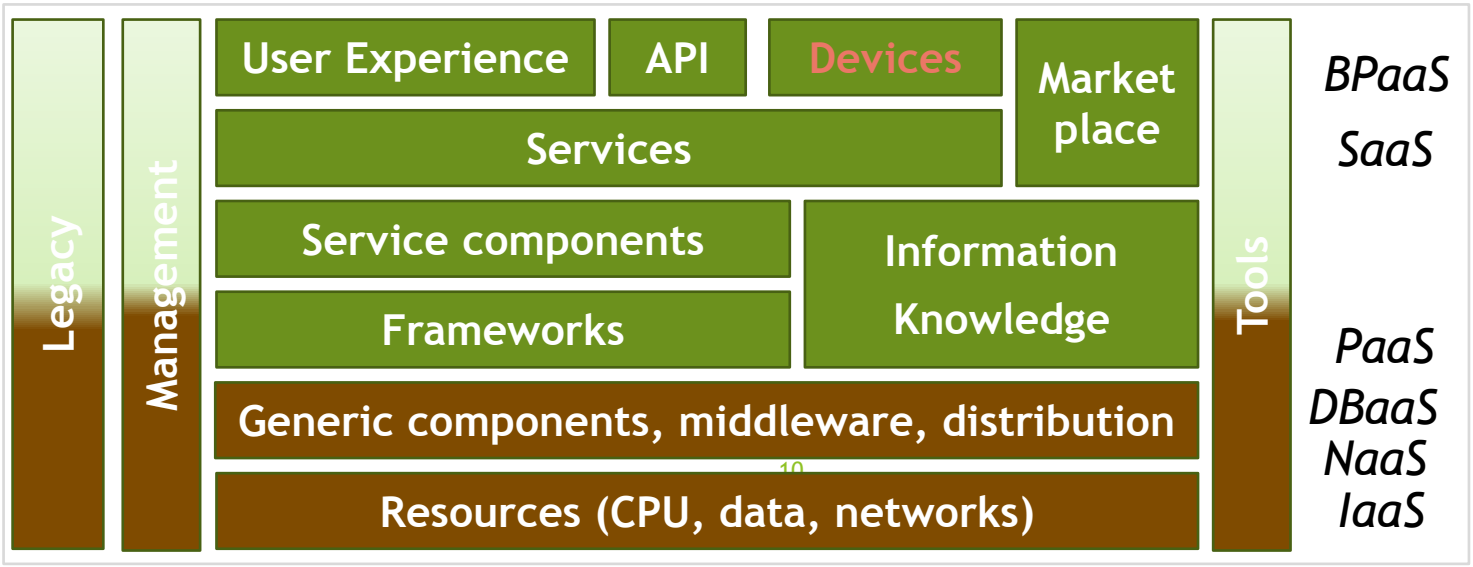
- Evolutions
  - virtualization and « softwarization » of networks
  - inter-cloud or distributed cloud
- Challenges
  - consistent security, scalability and dependability policies between layers (networks/servers) and between cloud instances
  - cooperation of virtualized and non virtualized systems

Cloud cartography : 2016 and beyond



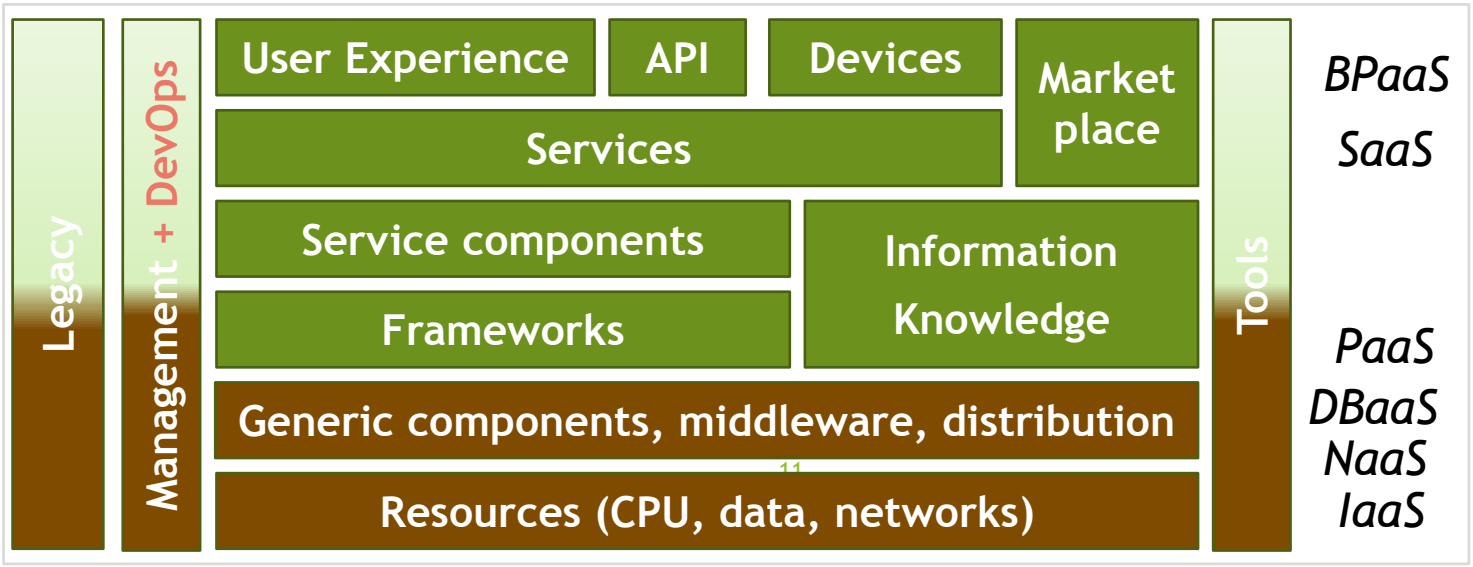
- Evolutions
  - data analytics as part of application
  - storage as native component of cloud solutions (objects, NoSQL…)
- Challenges
  - scalable and distributed data-management for the cloud (replication, fragmentation, transactions optimization,…)
  - consistent design patterns for the distribution and orchestration of services and data access (end of hierarchical N-tier architectures)
  - methodologies and tools to help design micro-services encapsulating data and processing (including the refactoring of legacy systems)

Cloud cartography : 2016 and beyond



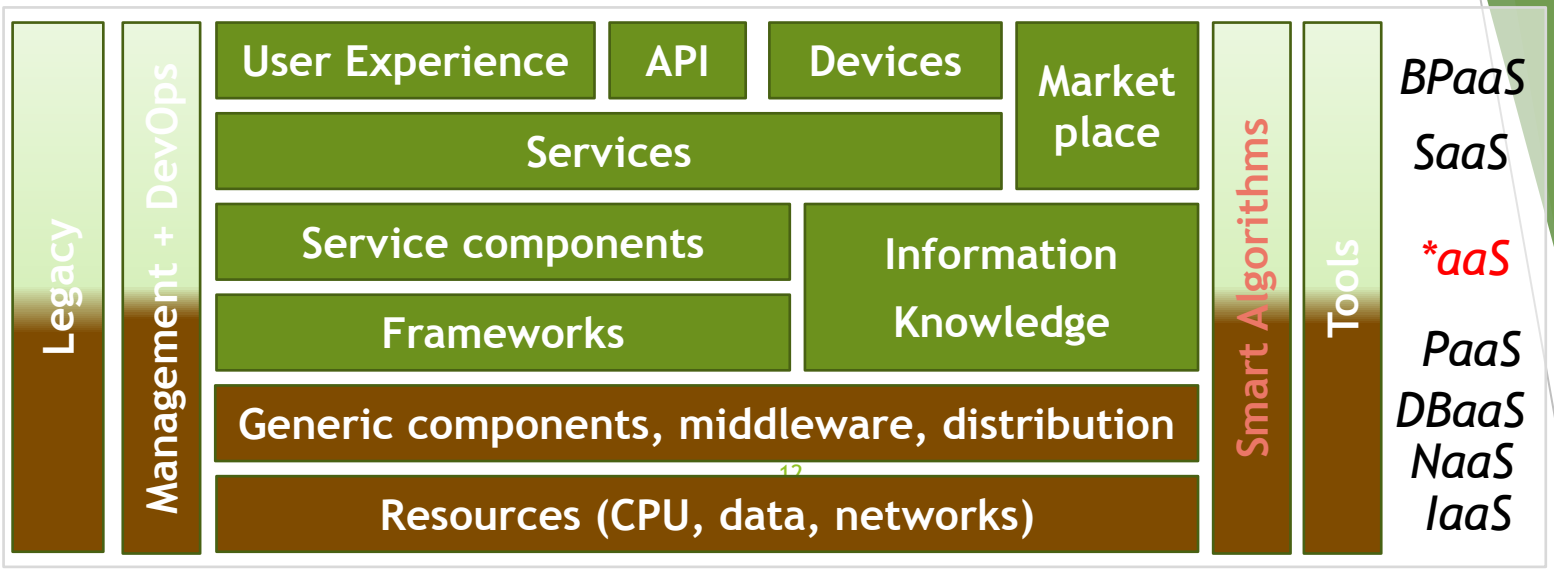
- Evolutions
  - support of IoT devices at the edge
  - migration of processing and intelligence to the edge
- Challenges
  - cloud SLA matching the requirement of critical cyber physical systems
  - cloud ready frameworks for real-time data collection, analysis and actuation (including « fog computing »)

Cloud cartography : 2016 and beyond



- Evolutions
  - agile deployment targeting clouds and devices (full stack frameworks)
  - multi-level management from usage to applications to infrastructures
- Challenges
  - mechanisms and tools for multi-tenancy spanning vertically networks, clouds and devices
  - consistent automation of deployment and management between layers (resources, middleware, services, users) including the management of security and privacy
  - cooperation of management function between actors (including SLA design and enforcement, cybersecurity functions)
  - tools to predict or simulate the behaviour of systems (infrastructure and applications) at design phase (simple to use, native in development and integration process, directly transposable in SLA caracteristics)

Cloud cartography : 2016 and beyond



- Evolutions
  - opportunities to leverage data available from all levels
  - autonomic loops, machine learning, policy driven processes, cognitive systems
- Challenges
  - holistic approach to complex systems (coordination between local decisions and global policies, including data management) : self managing software systems
  - run-time adaptation to evolutions of context, usages or requirements (executable SLAs)
  - cooperation of policies between the cloud and the edge (devices, users' information systems)

Propositions of priorities for discussion

- From cloud computing to a holistic approach of complex systems : complete computing, continuum,…
- New levels of abstraction for engineering : distribution, security, data, software, SLA, availability, performance => simplifying the design of robust and efficient services
- Policy-driven or intention-based deployment and management for infrastructures and services

Annexes

ICT Cloud WP evolution

- 2014
  - High performance heterogeneous cloud infrastructures.
  - Federated cloud networking
  - Dynamic configuration, automated provisioning and orchestration of cloud resources
  - Automated discovery and composition of services
  - Cloud security
- 2016
  - Deployment and management of densely interconnected and decentralised cloud infrastructures
  - Cloud networking
  - Trust, security and privacy in decentralised cloud infrastructures
  - Evolution of cloud architectures

Nessi Bibliography

- White Paper « Software Engineering : Key Enabler for Innovation » (2014)
- Response to the public consultation for WP 2016-2017 on Cloud Computing (2014)
- White Paper « Cyber Physical Systems : Opportunities and Challenges for Sotware, Services, Cloud and Data » (2015)
- White Paper « Security and Privacy : From the Perspective of Software, Services, Cloud and Data » (2016)
- Recommendations for the ICT Work Programme 2018-2019 « Software Continuum » (2016)