Swarm computing, realisation of Computing Continuum

Atos Vision for Future Cloud

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Agenda

1. Computing Continuum vision

2. Associated Technologies & Trends

3. Open Research Challenges in Edge and Cloud towards Swarm computing
Computing Continuum vision
very few actors are able to capture a comprehensive holistic vision embracing all the opportunities offered by this cloud continuum and even fewer companies are able to provide solutions able to make use of the full technology spectrum.
Cloud adoption is booming.
Underlying technologies are mainstream now, having reached a high degree of maturity and providing responses to more complex scenarios.
Cloud default platform for start-ups and many enterprise organizations have already fully embraced the cloud model.
Even though the maturity of implementations is not always at the same level and there remains uncertainty about the appropriate use of Public, Private and Hybrid cloud models.
Computing Continuum

organizations that aspire to lead the future digital business are pioneering solutions based on connected devices and IoT related technologies.

Maturity, standards and adoptions are in early stages even though there is a common consensus that these technologies as the next big thing.

investments and experimentation growing exponentially.
Swarm computing combines network and cloud principles in order to create an on-demand, autonomic and decentralised computing and storage management layer that transparently interoperates among diverse and disperse Edge and cloud models and typologies.
Associated Technologies & Trends
Cloud Service Integration
Edge Computing
Cognitive Computing
Internet of Everything
Smart Machines
Swarm Computing
Cloud Service Integration
Cloud Service Integration

- The new computing continuum will be a heterogeneous environment based on the decentralization and federation of diverse computing entities and resource typologies.

- These will include multi-cloud (and cloud federation) models with their diverse, decentralized and autonomic management and hybrid cloud models that cross boundaries between internal and external cloud services or between public, private and community providers.

- Cloud Service Integration (CSI) provides a flexible means for assembling these various cloud-based elements in support of business process that transverse IT domains.

- Compute workloads are deployed across multiple cloud environments to provide an optimal delivery model.
Cloud Service Integration - Multi-Cloud Scenarios
Cloud Service Integration - Multi-Cloud Impact

- Helps companies **balance functionality, flexibility and investment protection**
- **Reduces cost** by eliminating the need for hardware to **absorb peak demands, reducing overall management cost and energy consumption**
- **Accelerates** computing **resource delivery** while improving resource availability and **optimizing resource utilization**
- Helps small and medium companies **handle peak-loads**, acquiring additional capacity as and **when needed**
- **Brings workloads closer** to where **demand** is, eliminating unnecessary latency
- **Ensures compliance** with national regulations when customers have specific restrictions about the legal boundaries in which their data and application can be hosted
Cloud Service Integration Issues

▶ **Compatibility** across services is still an **open issue**, compromising further advance of inter-cloud service provisioning. **Cloud market leaders** are yet to widely adopt any **standardization efforts**, but **multi-cloud** may be the **market force** that pushes that **adoption**, breaking down current **vendor lock-in**.

▶ Multi-cloud environments **increase** the complexity of **service level agreements** since providers rely on diverse services from a more complex cloud ecosystem. Existing contracts will need to be analyzed and extended so **chains of contractual relationships** can be **automatically established** across multiple and heterogeneous cloud providers.

▶ Multi-cloud environments will need **virtual networks** to be set up across multiple cloud providers. **Yet poor network performance** is a **roadblock** for wider cloud adoption, while cloud federation requires extensions to the concept, **techniques** and **primitives** of **cloud networking**.

▶ The **constant changes in security parameters** enabled by dynamic multicloud management models is **amplifying current security concerns**.
Edge Computing

- The growth of the **Internet of Things (IoT)** and the emergence of ever-richer cloud services together **call for data to be processed at the edge of the network**.
- Edge computing is also referred to as fog computing, mesh computing, dew computing and remote cloud.
- It **moves applications, data and services away** from the **centralized model of cloud computing** to a more **decentralized model** that **lies at the extremes of the network**.
- **Ubiquitous** (and sometimes **autonomous**) **devices** — including the laptops, smartphones, tablets and sensors that may not be continuously connected to the network — **communicate and cooperate among themselves** and with the **network** to **perform storage** and **processing tasks** without the intervention of third-parties.
- Edge computing **covers a wide range of technologies**: from wireless sensor networks and mobile data acquisition to **distributed peer-to-peer ad-hoc networking** and **processing** and more.
Edge Computing Impact

- Brings **computation and storage closer to the source of the data**, ensuring the results of analytics and other processing are rapidly available and highly accessible to the systems that need most them.

- **Addresses latency issues** detected in large Internet of Things (IoT) scenarios.

- Conserves **bandwidth and reduces privacy and security risks** by eliminating **unnecessary network transmission** as an increasing number of ‘things’ and connected devices generate growing volumes of data.

- **Lightens the load of centralized cloud servers**

- Expected to enable a **broad spectrum of use cases and applications** for which **traditional cloud computing** is not **sufficient**.
Edge Computing Issues

- **Applications** written for an edge scenario will often need to work on heterogeneous environments.
- Data reported from different things may come in a variety of formats. **Standardization** is needed to enable interoperability among devices and sensors within both edge and traditional cloud environments.
- The potentially thousands, or even millions of small devices and sensors, in edge computing set-ups will require a new style of device management. This may potentially need to be decentralized and able to scale to degrees unprecedented in today’s existing cloud architectures.
- Envisaged as multi-tenant, edge computing set-ups will require specific isolation mechanisms to avoid security and privacy concerns.
Cloud Service Integration
Edge Computing
Swarm Computing
Swarm computing refers to massively distributed, self-organizing systems of agents that work collaboratively towards a defined outcome.

Each agent within the system has a simple set of rules to follow and only interacts with its local environment.

The aggregate behaviour of the agents leads to the emergence of ‘intelligent’ global behaviour.

With the number of nodes comprising the Internet of Everything (IoE) predicted to rise and many individual nodes likely have limited compute capabilities, each would be complimented by connection to other objects in a community — thus creating an IoE swarm.
Swarm Computing Impact

- Creates a **dynamic eco-systems** of **cyber-physical devices** and **clouds**, each adding to the **collective capability** and **insight**
- Allows **operations** and **interactions** to adapt according to **context**
- Improves **efficiency** and **reliability** of **service provision** through:
  - Enabling **ad-hoc collaborations**, which help **build service networks**
  - Optimizing **delivery schemes** and **communication patterns**, which allow information and services to be **shared** and **exchanged**
  - Creating reliability and **dependability** from **volatile resources**, which help manage uncertainty
- Allows work to be **distributed** across **simpler devices** (or robots)
- **Complements** other **forms** of **artificial intelligence**
- Provides a **significant step** toward **massively distributed computing models**
Agent-based programming is complex and skilled practitioners are not easy to come by at this present time.

Integrating swarms with other centralized control mechanisms is also complex.

Security is a huge concern, especially if individual robots within a swarm are under the primary control of different individuals or organizations.

Communication protocols need to be standardized to enable flexible and dynamic interaction.

There is a possibility that non-deterministic behaviours, including unexpected or out of control ‘emergent’ behaviours, may emerge.

- Swarm viruses, where swarm behaviours are influenced adversely by rogue components, may also emerge.
- These would have huge implications in use cases such as driverless vehicles.
3 Open Research Challenges in Edge and Cloud towards Swarm computing
Swarm Computing requirements

- Swarm hyper distribution of computing will have to enable cloud computing continuum scenarios to consider
  - interoperability
  - portability
  - elasticity
  - self-organisation
  - self-management
  - self-healing
- Across many and heterogeneous resources
- In Edge clouds, private enterprise clouds, aggregated cloud models and large Cloud set-ups
Cloud Service management / Multi-Cloud

Cloud Service Integration - Multi-Cloud

Public Cloud

Cloud Broker

Private Cloud

Computing Continuum

Swarm Computing

Edge Cloud

Service Management / Advanced Cloud Capabilities

Mobile “Things” Clouds / Edge Computing
Cloud & Edge computing @ Atos

Atos Bull Sequana Edge Computing Box (prototype)

Atos Codex offerings, is already a significant player in the IoT marketplace.
Other Resources and Materials

- Atos Lookout
  https://atos.net/content/mini-sites/look-out-2020/

- Atos Scientific Community
  - Journey 2022
    https://atos.net/content/mini-sites/journey-2022/
  - Swarm Computing Whitepaper
Thanks

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