Seoul

Enabling Future Communication Paradigms

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GFI Summit

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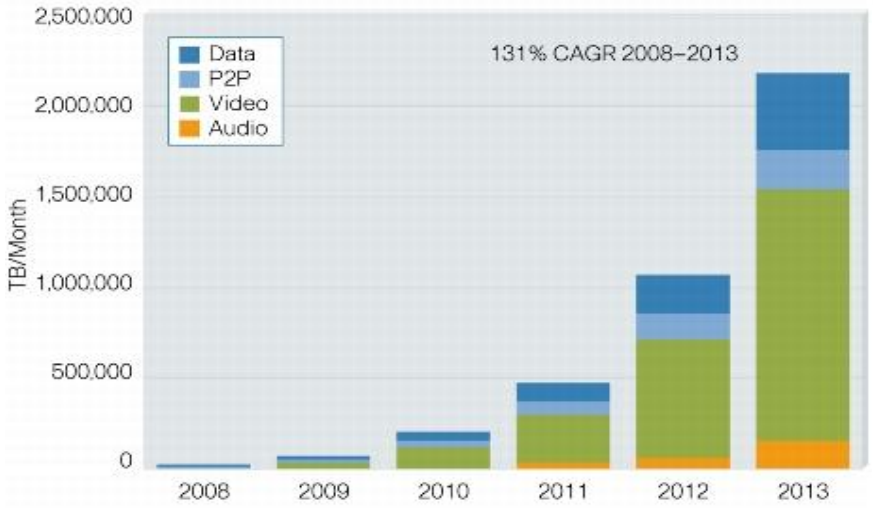
RAD data communications

Yes, it is *in particular* about traffic explosion

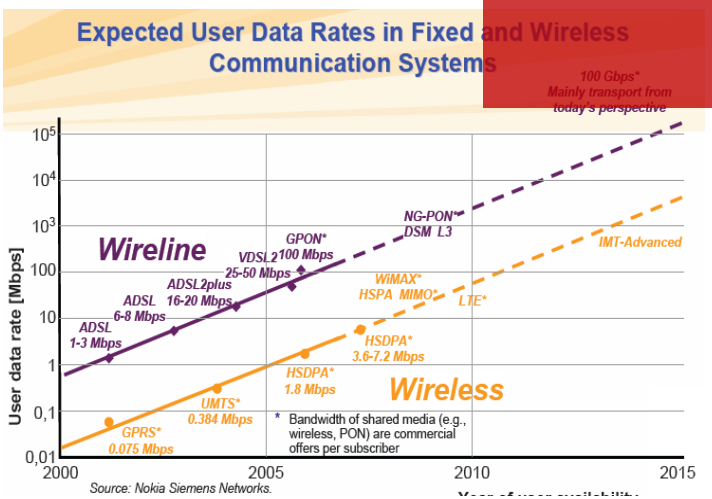


Forecasts 2 Exabytes per Month of Mobile Data Traffic in 2013 worldwide

Potential Growth in Data Traffic from a Single Mobile Subscriber

Source: Cisco

But mainly about new lifestyles and new business models



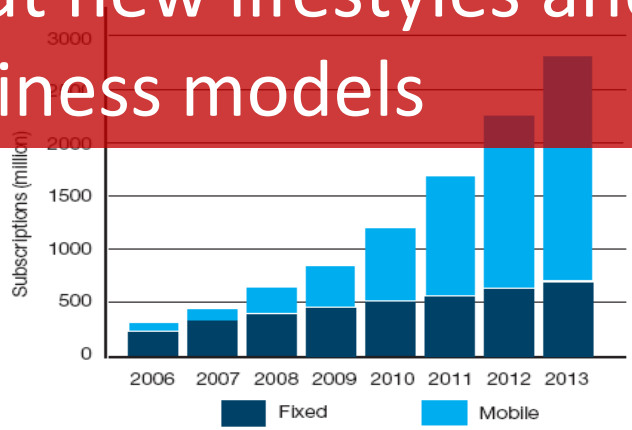
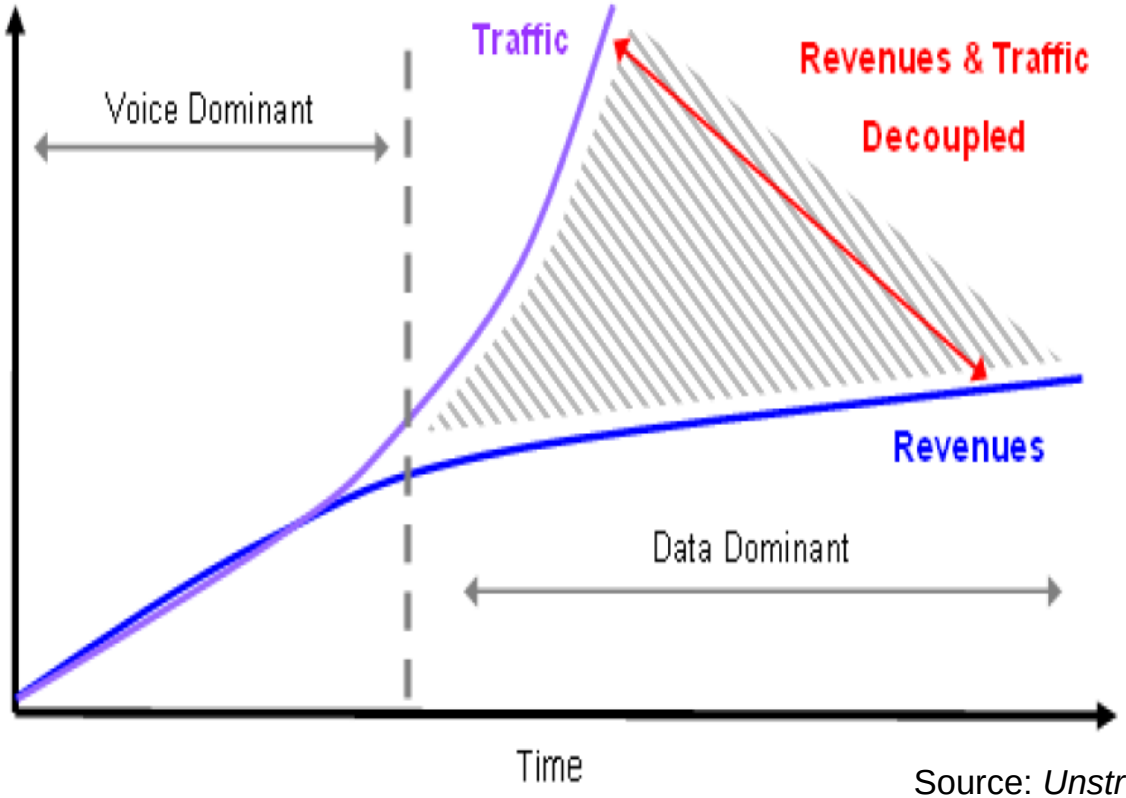
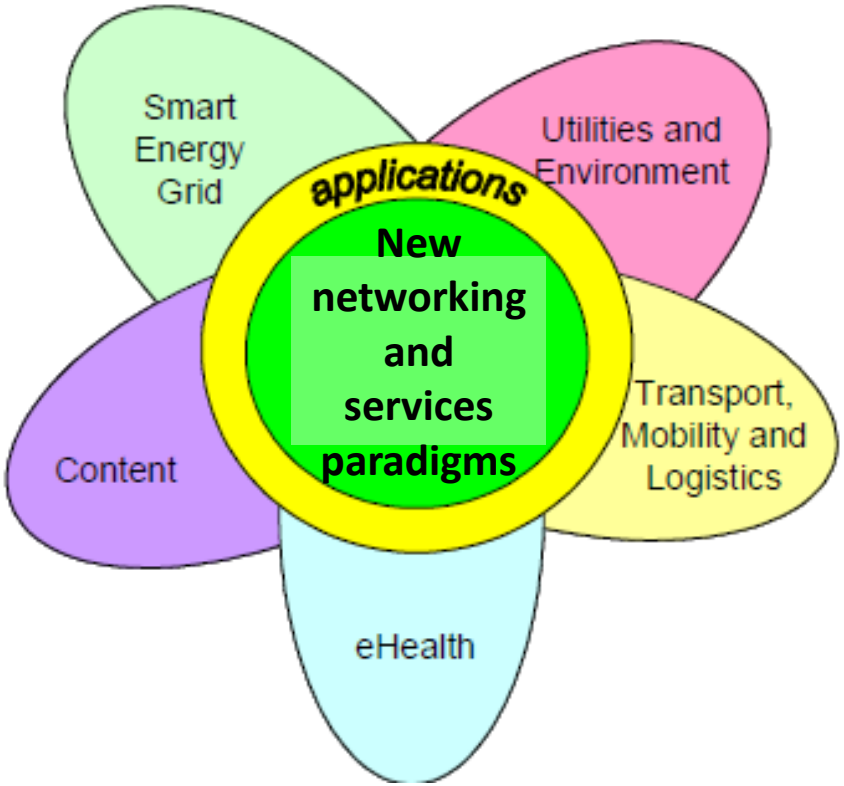


Figure 1. Estimated number of broadband subscriptions worldwide to 2013.²

Sources: Ovum, Wireless Intelligence, Strategy Analytics, Gartner and Ericsson calculations/extrapolations

Yes, It is *in particular* about cost



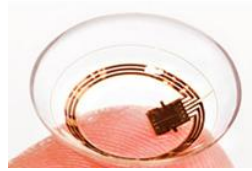


Source: *Unstrung Insider*

But mainly about new value proposition, business opportunities and business models

Societal impact of future services

- **ITC** : At the core of **key innovations with very high socio-economic impact**
  - **Health** : distant and continuous monitoring of health state, support of elderly at home,…



  - **Transport** : Vehicular networks for road security, Smart Cities, Multimodal Transports, …
  - **Energy Optimization:** Energy grid, sensor and dynamic control of (home, building,…) automation systems, …
  - **Media** : Semantic search inside social networks, autonomic creation of new content and media,…
  - **Disaster Management** : self-organized systems based on users' devices (smartphones and beyond), …
  - **Environment, Industrial Processes, Enterprises Service Oriented organizations,** …

Trends

- A quick view on present major ICT trends accentuate the followings :
  - cloud computing; predominance of content and new content distribution paradigms; Internet of Things, cyber-physical systems, smart systems (e.g. in health, energy, environment domains) and smart spaces (e.g. cities); social networks paradigm extending to the enterprises; composable enterprise architectures, advanced information systems, crowdsourcing; the usage of semantic approaches for data mining (business intelligence, stream reasoning...) and the related emergence of new media, and of course global mobility, broadband access high capacity core, among others.

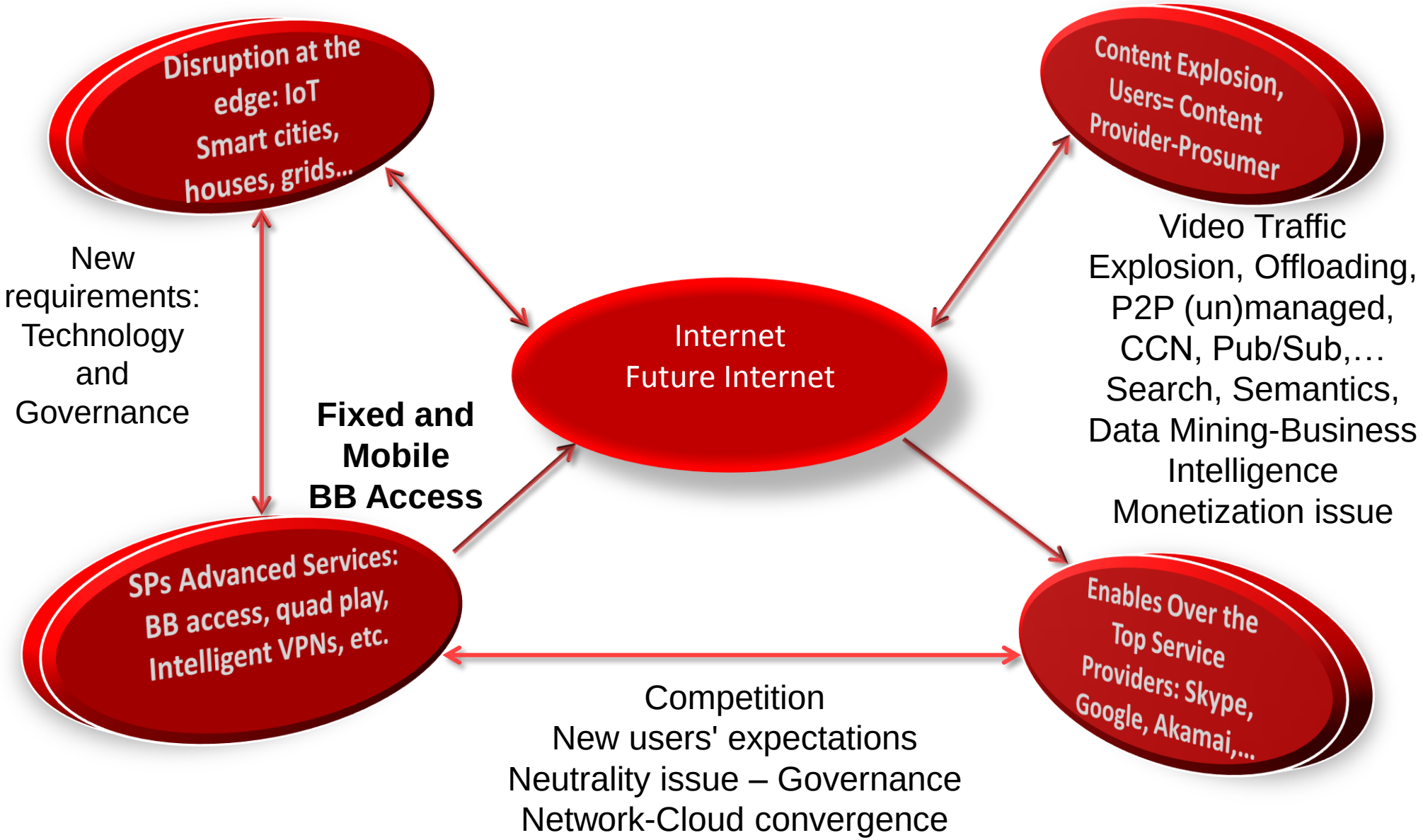
Trends

- For the long term, nanotechnologies have been promising much more disruptive trends
  - Nevertheless the actual emergence of complex (self-organized) nano-machines, robot swarms, and systems alike require disruptive new communication paradigms pertinent at nano scales, a quite ambitious research challenge.

Integration, Interoperability

- The listed trends are usually treated quite independently one from each other.
- There is a need for their integration
  - a critical global research challenge since progress in this area will enable a broad set of new services and usages
- We propose a general framework for achieving such integration.

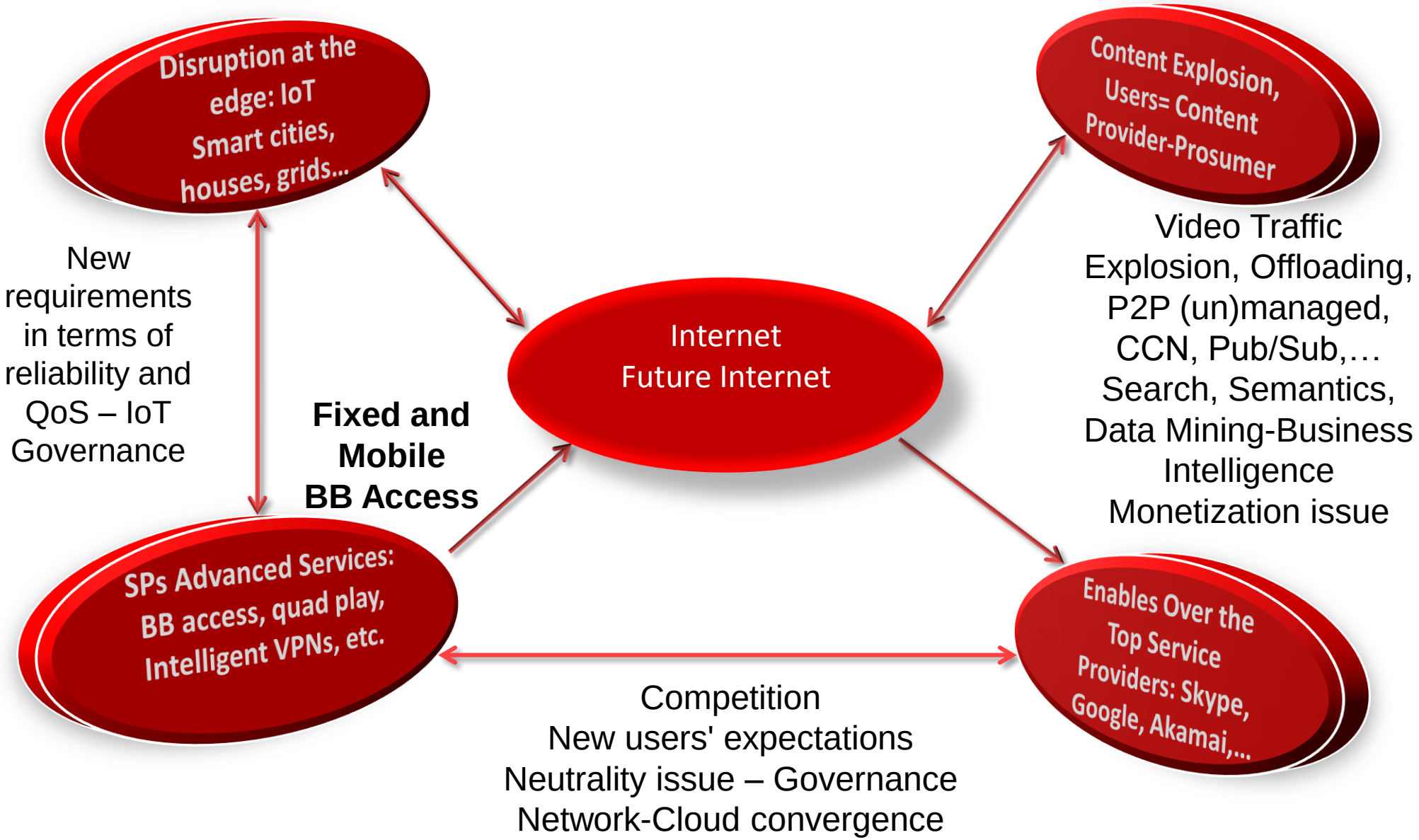
The present situation, and beyond



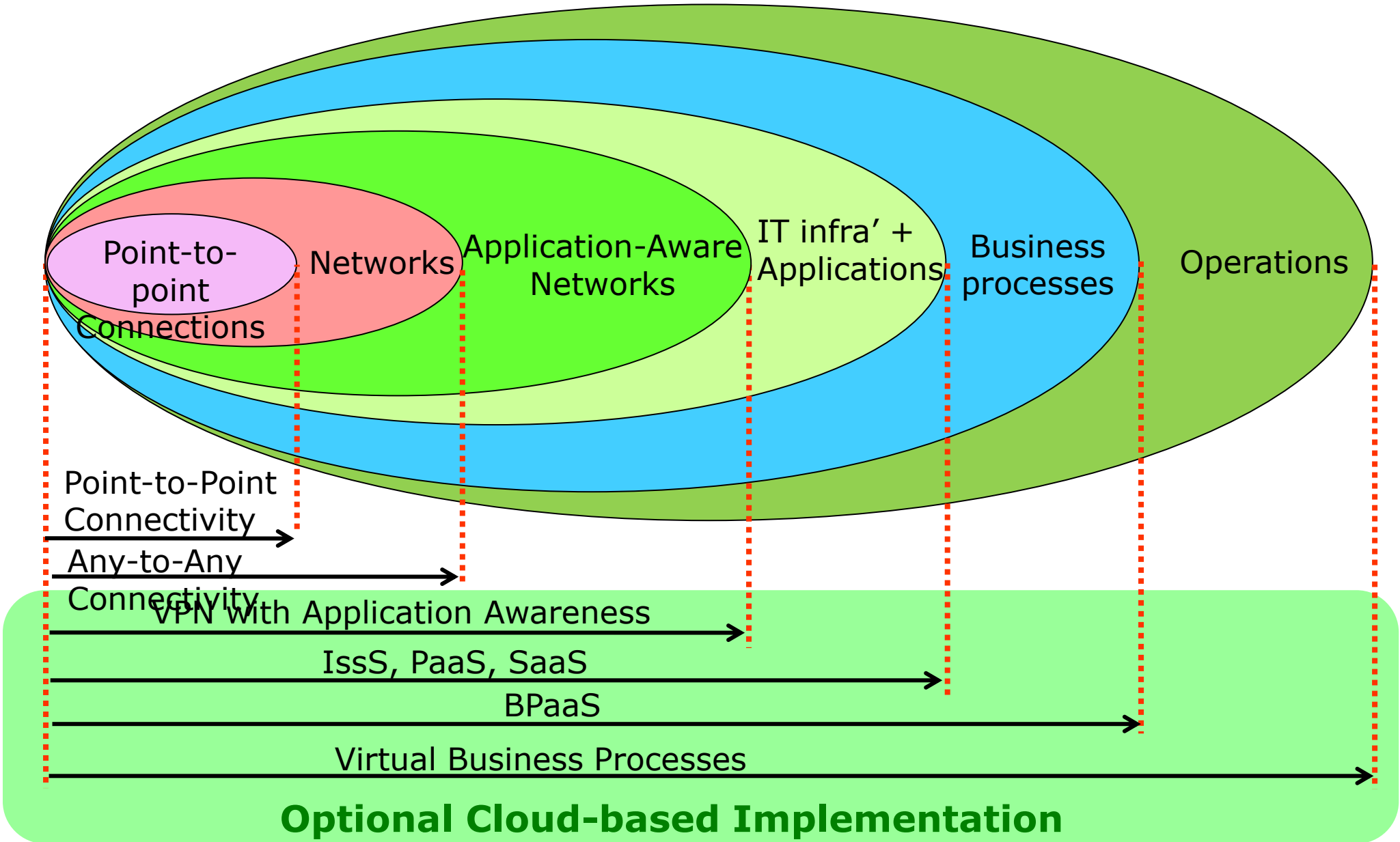
An evolving eco-system

- The dynamics of the communication domain are constrained by an evolving ecosystem :
  - the historical borders between “relevant markets” are vanishing and where several players claim that the business models didn’t evolve to fit these changes.
- The ongoing debates on neutrality, privacy and security, among others, are the logical consequence of that state of affairs.
- The complexity comes from the fact that when looking at these issues without the bias of particular interests:
  - providing appropriate answers require much deeper studies and analysis far beyond the usual arguments
  - the issue represents per se a research challenge.

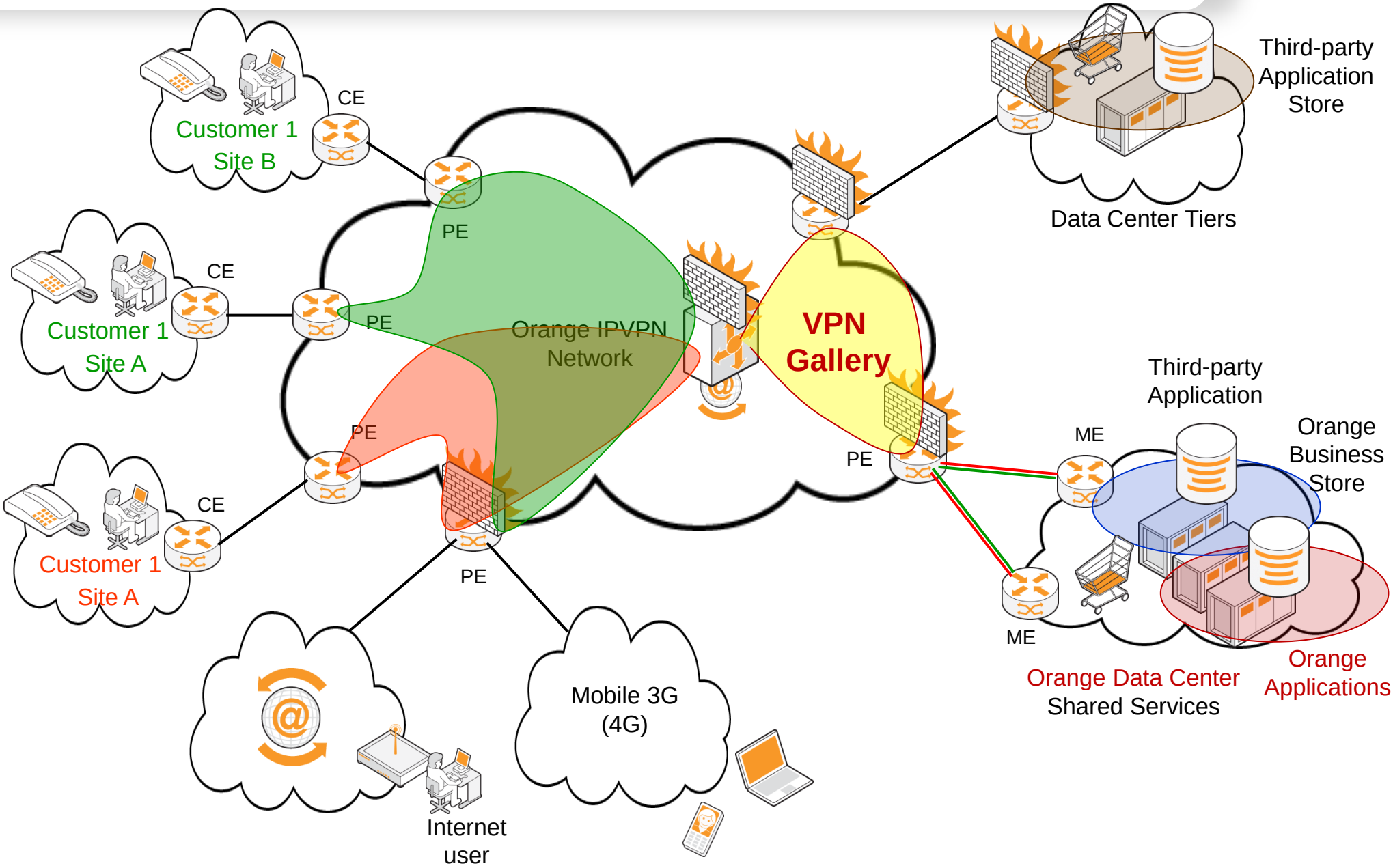
The present situation, and beyond



Example of Cloud – Network Convergence



VPN and cloud integration

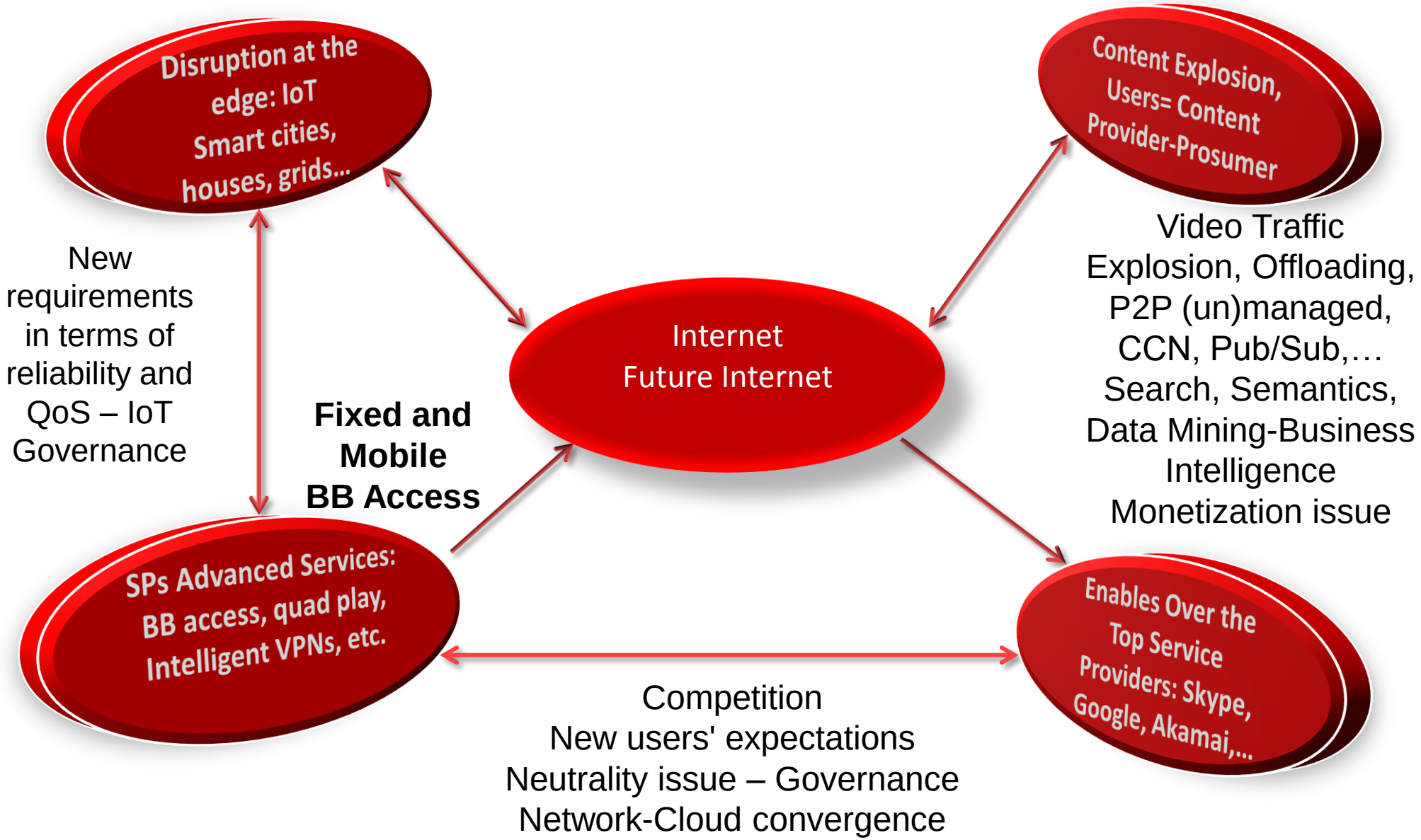


Courtesy of Orange

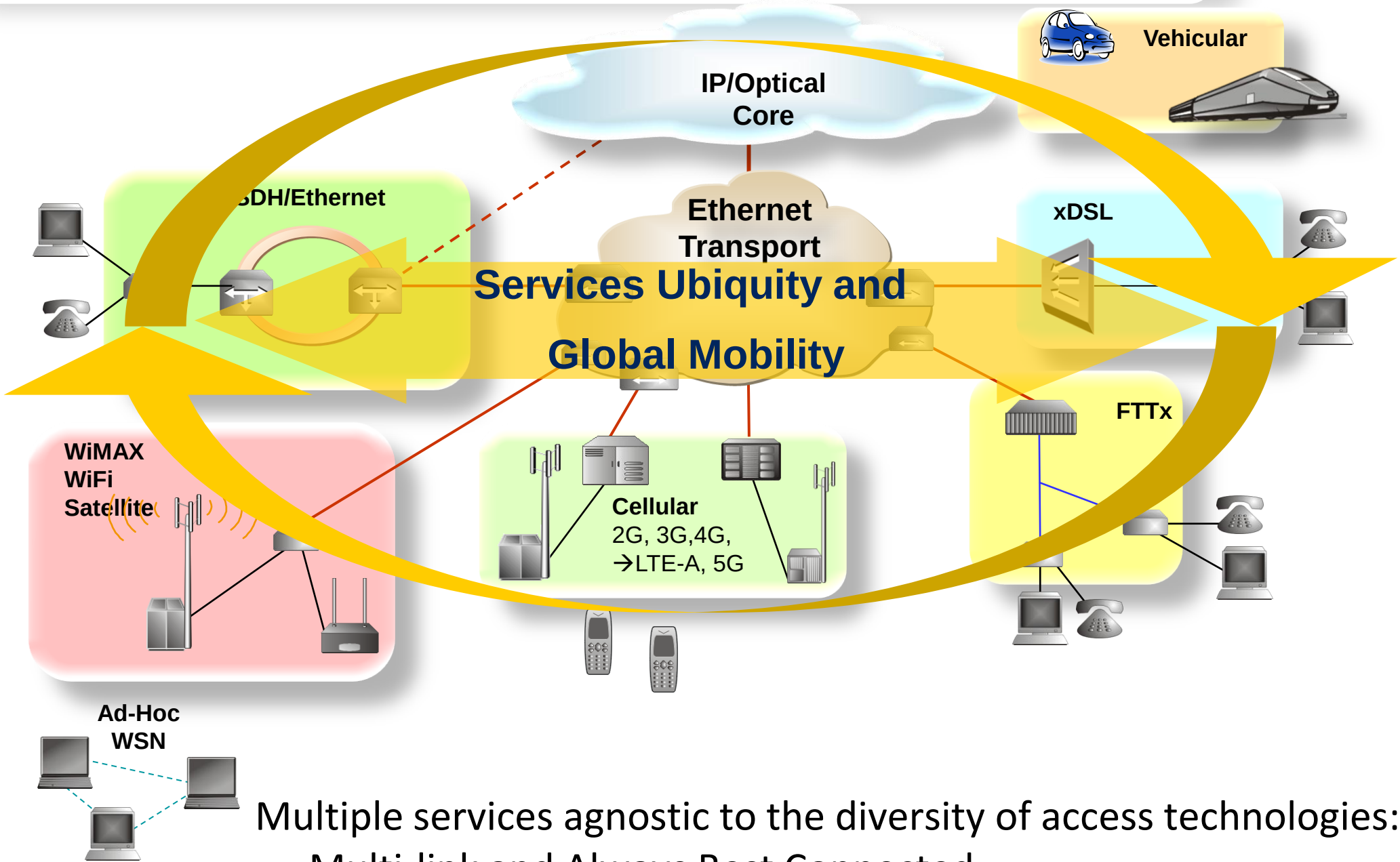
Clouds, Nano-clouds and Pico-clouds

- Cloud computing is introducing scalability and efficiency
- Residential gateways and Corporate CPEs will participate to the cloud
  - Cloud awareness: End-to-End monitoring, Cloud selection, Load balancing, Traffic control,...
  - Integral part of the cloud
- And mobile devices so will do
- Broadband Mobile devices
  - Will participate to advance content distribution systems
  - Will become the smart gateways between a large diversity of edge systems, including personal area networks, and the Internet

The present situation, and beyond

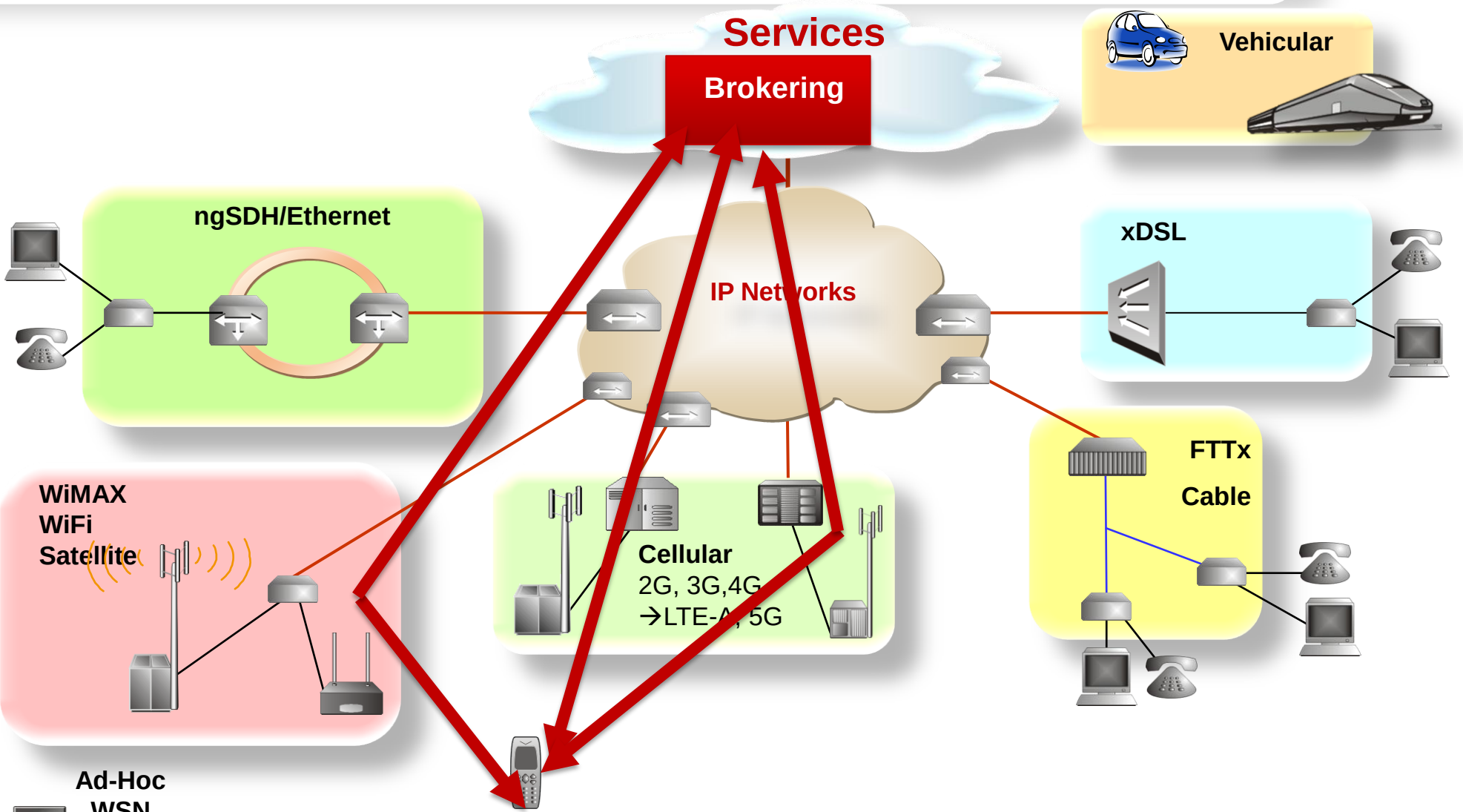


Ubiquity of Personalized Services



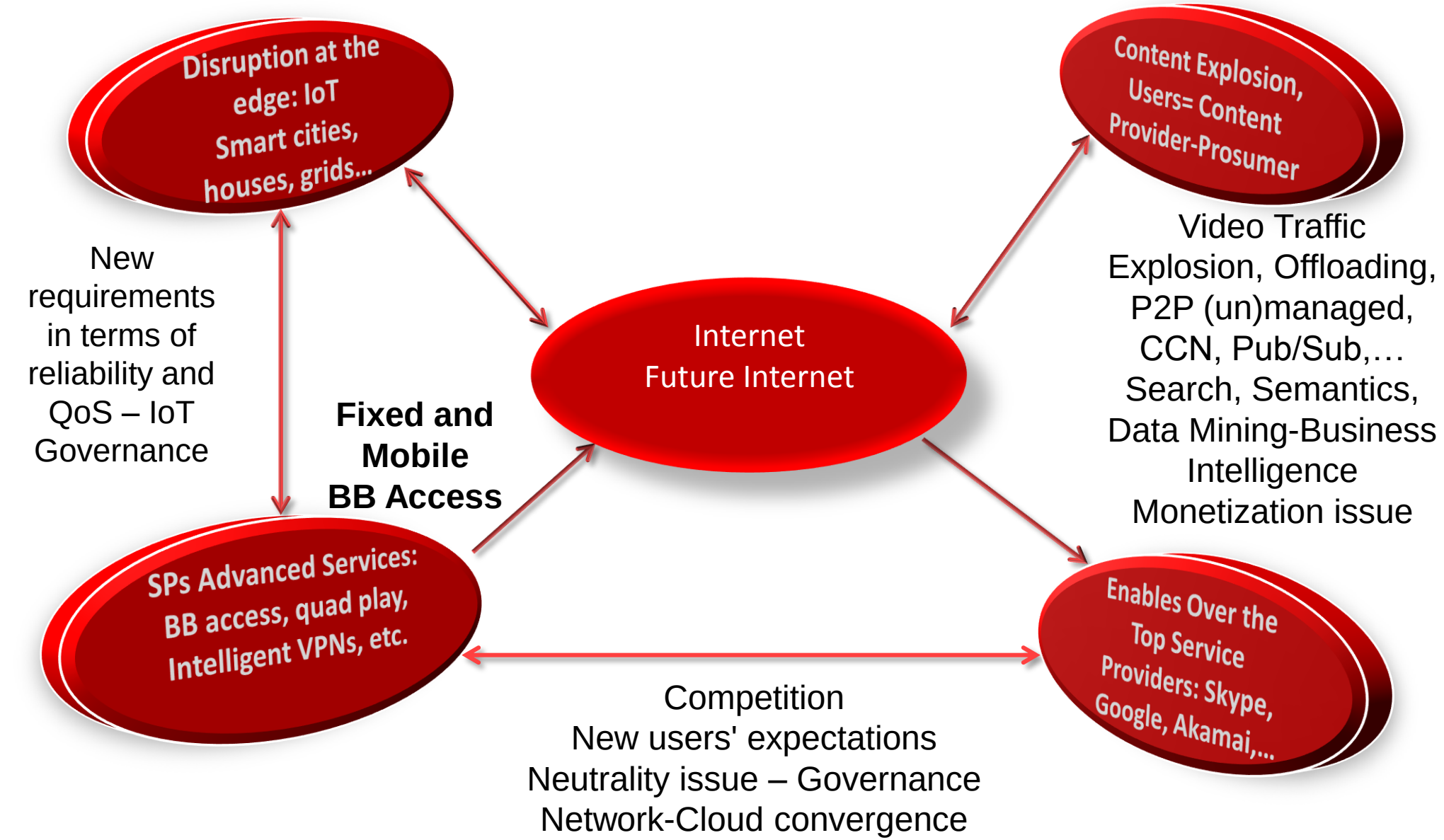
Multiple services agnostic to the diversity of access technologies:
Multi-link and Always Best Connected

Services Ubiquity and Global Mobility, Brokering



- Multiple services agnostic to the diversity of access technologies
- Multi-link access

The present situation, and beyond



Evolving meaning of content

- Usually when hearing about the evolution of content, we think about video
  - Indeed, it is well known that video traffic is exploding (related to the growing impact of “prosumers”, streaming, P2P, social networks…).
- **Content is growing in volume but also in diversity.**
  - WSNs, Internet of Things, Cyber-physical systems
    - things of our current life can provide their identities, to geolocate, to describe their capabilities, to store their history and in particular to keep track of their encounters and exchanges…
    - Very dynamic and mobile content sources. Capturing, storing, processing and distributing this type of content raises technological challenges that are far beyond those of distributing audio and video.

Evolving meaning of content

- Requirements seem much beyond those covered by ongoing studies on content driven networks, like Content Centric Networks or Named Data Networking.

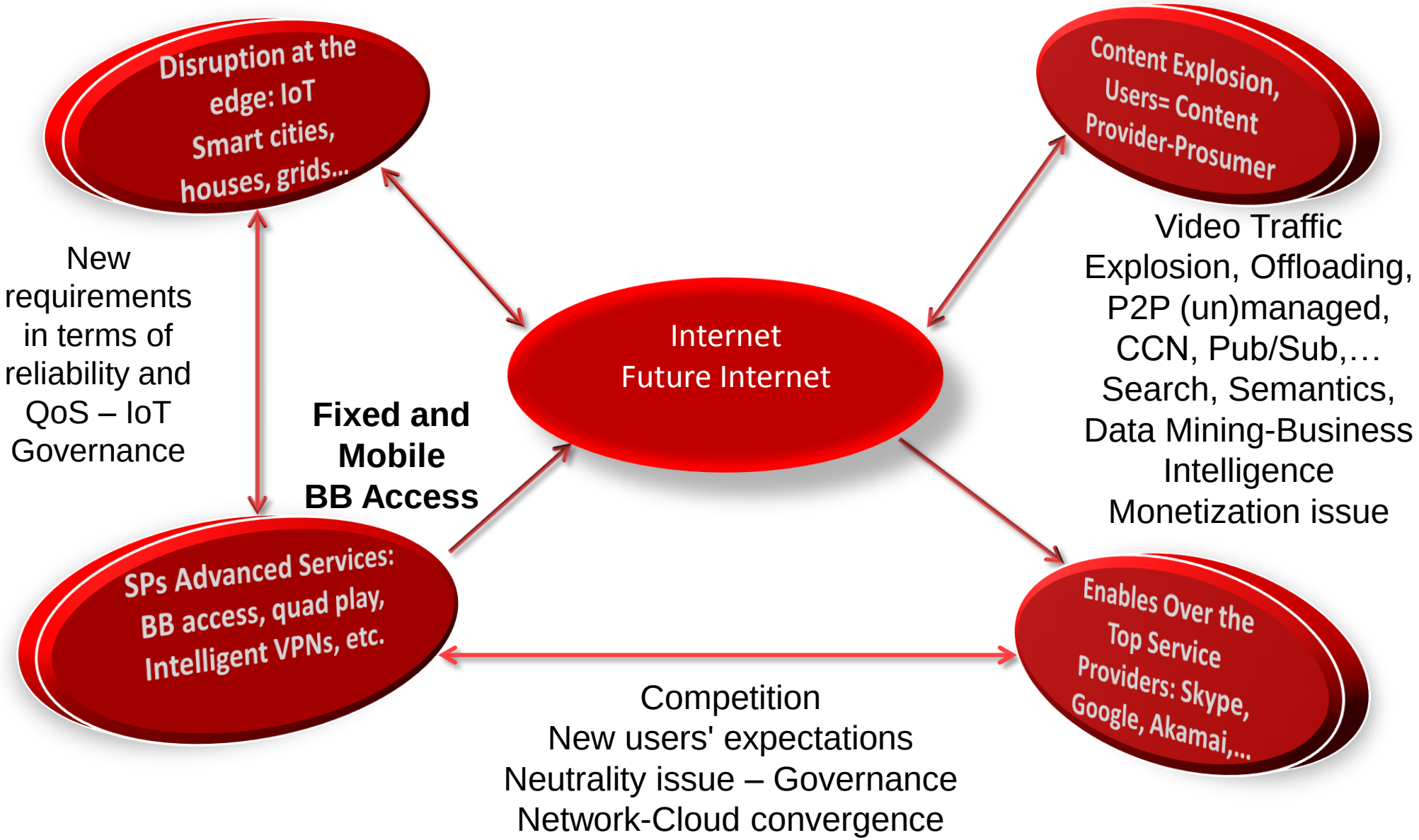
Evolving scope of cloud computing

- The cloud computing industry has been mainly focused on centralized architectures, where cloud resources are mainly deployed in very large data centers.
  - Mobile Cloud usually refers to the capacity of accessing the cloud through mobile devices.
- The cloud will most probably spread out of data centers and eventually reach the Internet of Things (IoT) and cyber physical systems.
  - Interconnected things will have the capacity to jointly store and process information
  - The location of the generated content will be distributed in an optimal way between the IoT local systems and other cloud components.

Evolving scope of cloud computing

- For example, self-discovering things in a specific environment can be done
  - partially by consulting a database located in a centralized part of the cloud
  - partially by locally discovering and communicating with things that can therefore be very mobile and evolving.
- Smartphones and then cyber physical systems will become integral parts of he cloud (e.g. storing and processing information)
  - nanoscale machines having advance capacities of processing the matter and self-replicating.
- The general architecture for heterogeneous cloud interoperability at various scales, technologies and administrative domains (building the cloud of clouds), represent a research area with high potential impact; the requirements are far beyond those covered by present inter-cloud and cloud portability efforts.

The present situation, and beyond



On the usage of semantics

- The semantic web (usually named Web 3.0) historically refers “just” to semantic searches and has not reached yet the expected success.
- The usage of semantics is broadening out of the semantic web.
  - New applications based on new technologies, like the so-called stream reasoning, have the capacity to analyze in real time the information exchanged in particular over social networks, do semantic analysis, correlate pieces of information and therefore perform some level of validation of veracity.
- By automatically organizing new information these applications enable a new generation of media able to publish news before any traditional one, as well as better performing business intelligence applications.

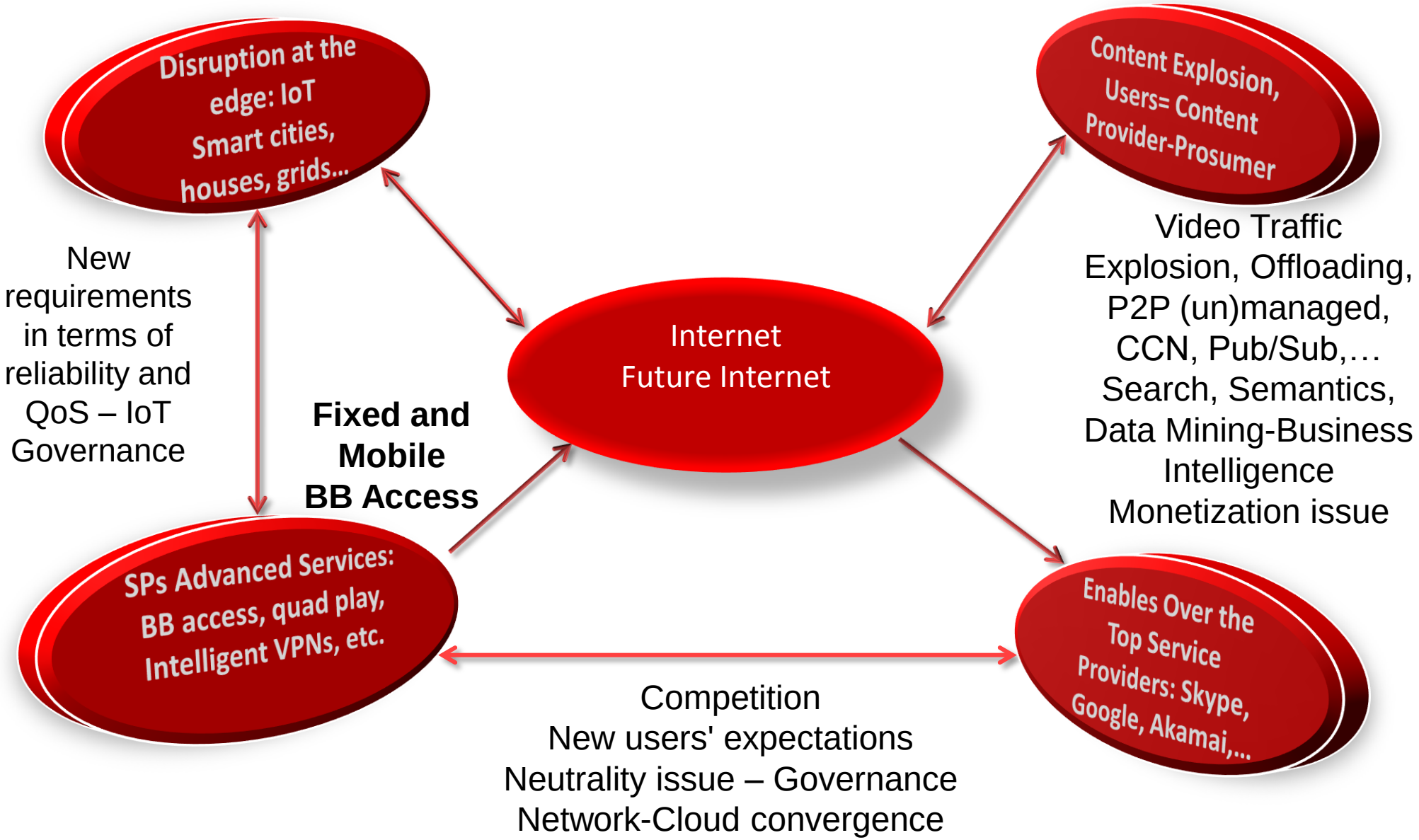
On the usage of semantics

- The control of real-time acquired information has an enormous political and economical potential impact.
- The related technologies remain quite immature and deserve special attention.

Towards the Web 4.0

- Web 2.0 and the interactive services
  - Social networks and the synchronous web
- Web 3.0, the semantic Web
  - Semantic Search
  - Stream reasoning
    - "By treating mobile phone users themselves as sensors, mobile applications could provide an understanding of the urban environment and its structure"
      - Emanuele Della Valle et al.
  - Business Intelligence
- Web 4.0, Semantic based self-organization of asynchronous and synchronous services
  - Semantic on dynamic social networks
  - Semantic based services composition

The present situation, and beyond

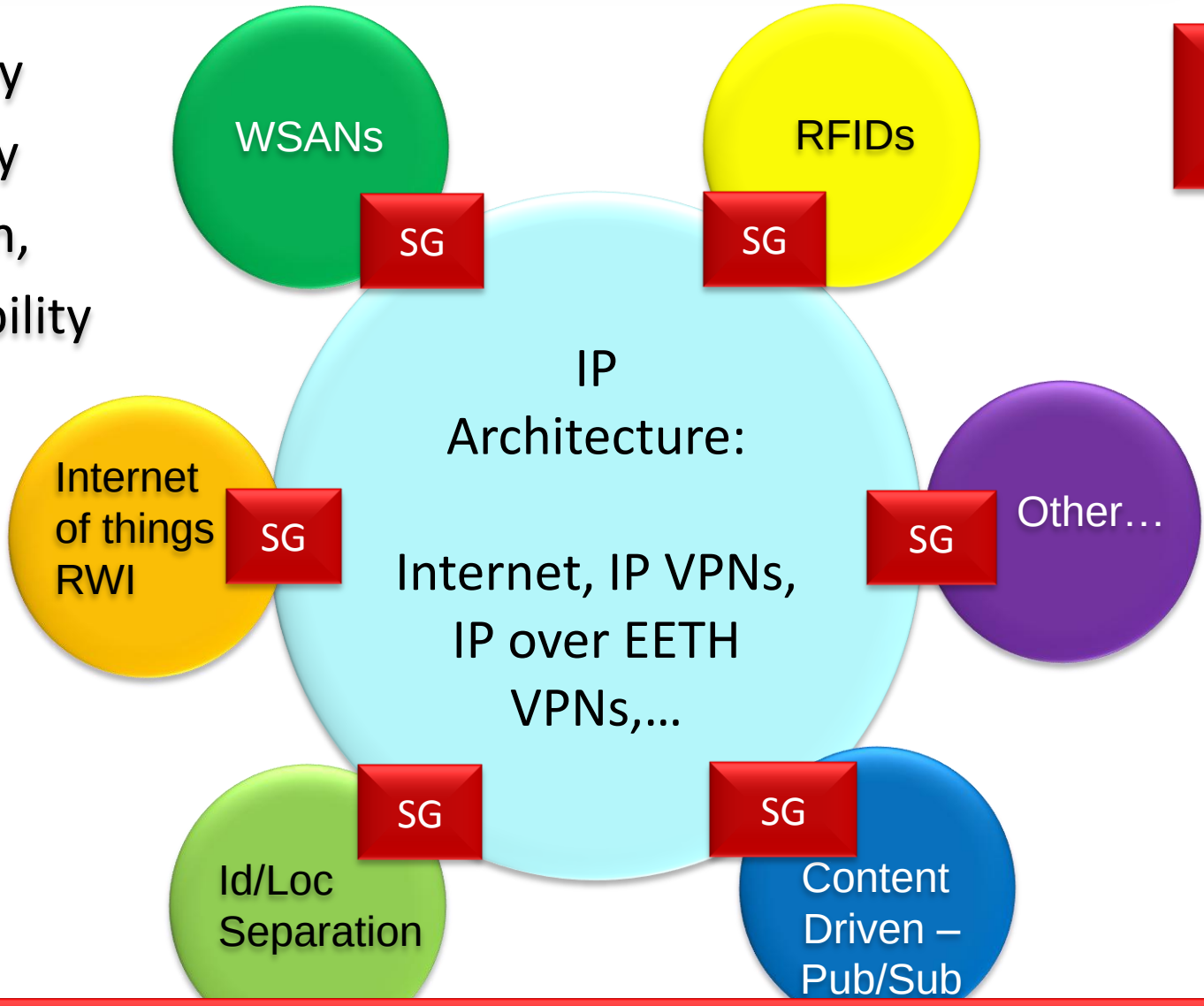


Integrating future communication paradigms

- A broad diversity of new paradigms will continue to emerge at the edge of the Internet.
- Users are no longer interested in connecting to a server but on reaching information/content generated by a broad diversity of entities (from friends to things) and to interact with local and distant, hybrid physical/virtual, environments (e.g. through nanites and avatars).
- Limitations of the Internet architecture, far beyond networking issues
- An evolving architecture has to be based on the semantics of the services
  - Understand users (human beings, machines,…) requirements and dynamically self-organize to provide the expected experience

Perspectives: Polymorphic Networking Environment

- Composability
- Autonomicity
- Virtualization,
- Programmability



Towards a mesh of new networking paradigms:
Central Role of CPEs, and of Smart Mobile Devices

Integrating future communication paradigms

- From locators (URLs), addresses and routing towards semantic identifiers and semantic routing.
- As mentioned, the cloud will encompass the Internet of Things as well as other cyber-physical systems.
  - The indicated semantic gateways will enable the “interoperation” of very heterogeneous clouds to build the global cloud of clouds, far beyond the present inter-cloud and cloud portability efforts.

Conclusion

- The network of the future will be polymorphic
  - Interconnection of systems with a large degree of architectural and technological diversity, at all possible size scales (from large data centres' based clouds to nanites).
- The dynamicity at all time scales of future services that will escape to the designers through the self-organization capabilities of the overall system
  - imposes new architectures - design has to be driven by this targeted flexibility.
- Self-organization is taken here in a very broad sense, far beyond the usual services self-configuration or self-healing.
  - In the future it may include the capability of things of self-replicating

Conclusion

- The interconnection of the evolving new paradigms cannot be performed at the network level but requires an understanding of the semantics of services, applications, content and things interfaces.
- Some of the paradigms will spread into the IP networks, leading to an evolution of their architecture.
  - As an example, content driven paradigms may progressively extend the core Internet architecture.
- Nanotechnologies have been promising much more disruptive trends; nevertheless the actual emergence of complex (self-organized) nano-machines, robot swarms, and systems alike require disruptive new communication paradigms pertinent at nano scales

Conclusion

- Ubiquity of broadband access, everybody and everything connected and collaborating, innovative applications
  - What a wonderful world!
  - So many business opportunities! But, for whom?

Thank You

Questions, Remarks,
Contributions, …