FIArch meeting
Feb. 22nd, 2012
Brussels, Belgium

Internet Design Principles
New Seeds

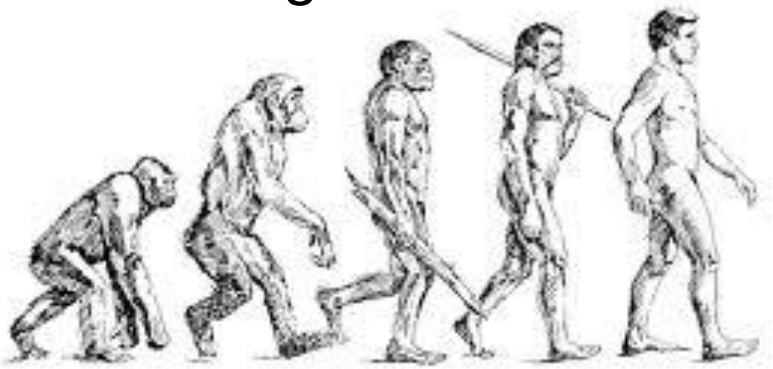
Ioanna Papafili
Athens University of Economics and Business

Outline

- Motivation
- What is a new seed
- Seeds
  - *Resources Awareness*
  - *Dependability Logic*
  - *Exchange of Information*
  - *Sustain the Investment*
- Discussion

Motivation

- So far we have seen existing principles that should be preserved / adapted / augmented
- Yet, the Internet has long evolved



- New *challenges* emerge that go beyond the networking and primitive service aspects
- Existing design principles may be unable to address them!

What is a new seed

Definition

A concept or a notion at the inception of a well formulated design principle

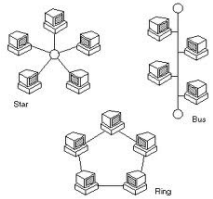
- Why seed and not principle?
  - Formulating principles is a complex exercise
  - Ongoing research in proving their value, utility and impact
  - Seeds may flourish while others may not

?

Resources Awareness

Challenges

- *Resources* have a physical representation and purpose
- Resources refer to infrastructure or services
- Infrastructure resources (network, storage, computation, etc.)



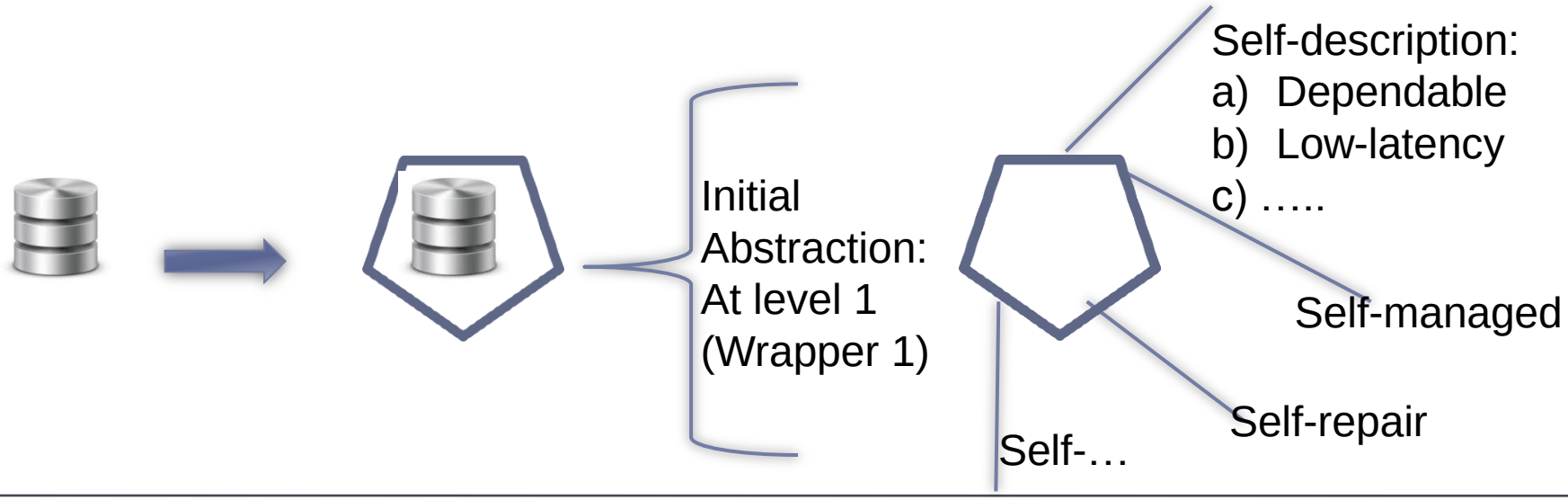

- Services: means for users to have controlled access to functionalities/information offered over the Internet
  - Service components, e.g., commercial services as black boxes
- Infrastructure is service-unaware
- Growth of data requires new delivery schemes that overcome limitations w.r.t. efficiency

Resources Awareness

Seed

- FI should include resources as first order abstractions
- Network should be able to manage as a whole these abstractions
  - Making the resource self-* explained:

    initial functionalities (initial abstraction)



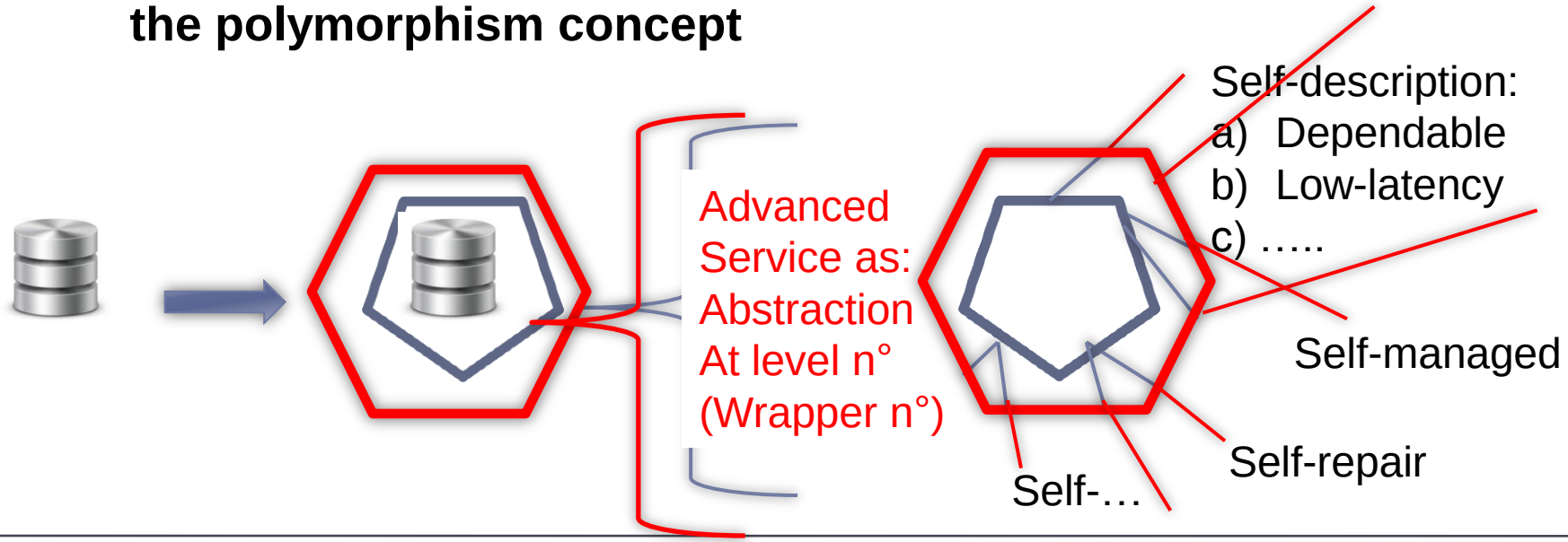
Resources Awareness

Seed

- New resources should be aware of underneath resource capabilities
  - Making the resource self-* explained:

    initial functionalities (initial abstraction)
  - Improving and adding new functionalities/capabilities:

    the polymorphism concept



Resources Awareness

Impact

- *Service Delivery*
- Infrastructure optimization exploiting service behavior information

Interaction with other principles

- “Modularization by layering”
  - Enhanced cross-layer cooperation based on functionality descriptions
- “Loose-coupling”
  - Minimized interactions and non-linear effects through cross-layer awareness
- “Locality”
  - Reduced distance between processes and data

Dependability Logic

Challenges

- Lack of methods/means for reliable, accountable and verifiable processing and handling of inftrastucture w.r.t. *services*
  - Services not a *'cure-all'* – not cognisant of users' needs
  - Services operate on a *'best-effort'* basis
  - Little or no service guarantees to the end-user
  - Services are modelled prior to their deployment
  - Infrastructure is *service-unaware*

Dependability Logic

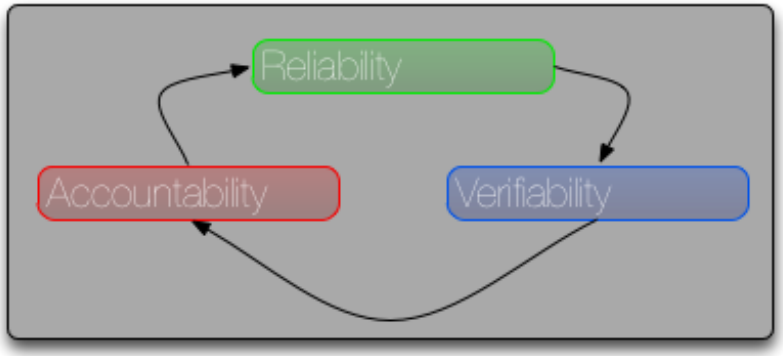
Seed

- Future Internet must be imbued with and extend the *Principles of Dependability*
  - *Availability*
  - ***Reliability***
  - ***Accountability***
  - ***Verifiability***
  - *Safety*
  - *Integrity*
  - *Maintainability*
  - *Confidentiality*

And **be further enhanced** by:

- Transparency
- *Self-adapation* and *self-learning* capability

Feedback-loop: Transparency



Self-adaptation
Self-learning

Dependability Logic

- The definition should cover **Transparency**

Transparency: the ability to inspect and introspect a service so that the delivered and guaranteed quality of the service agreement can be verified and observed.

- 24 years of work. Finalised in 2004 (IEEE)
  - Little consideration for the Internet of services, where end-users are **service**- and **not product**-oriented

Dependability Logic

Impact

- Tackles the issue of lack of trust of interest to many enterprises/SMEs, service broker, users
  - Use of many cloud services today (IaaS, PaaS, SaaS)

- Service providers *may* offer guarantees
  - Very difficult for the customer to *verify* these
- Requires a new introspection capability*
  - Both in Service and Network domains

* Recognized by the UK in the areas of converged Future Internet services: "Fundamental Limitations of Current Internet and the path to Future Internet"

Dependability Logic

Interaction with other principles

- “Modularization by layering”
  - Application: Two or more levels of dependability management
- “Loose coupling”
  - Application: Management differing levels of abstracted services and resources
- “Polymorphism” principle
  - Application: Service self-adaptation based on promised guarantees; different characteristics as parameters of the polymorphism behavior

Exchange of Information
between communication end-points

Challenges

- Internet evolved to a playground of various stakeholders
  - Stakeholders perform *individual* optimization,
  - Stakeholders *ignore* information related to others
    - Possibly beneficial to themselves and society
- Internet is *unpredictable!*
  - Designers cannot foresee whether an outcome will be the most efficient and beneficial one
  - Outcomes should not be impose

Therefore:

- Address *Information Asymmetry*
- Allow for *variation* in outcome*

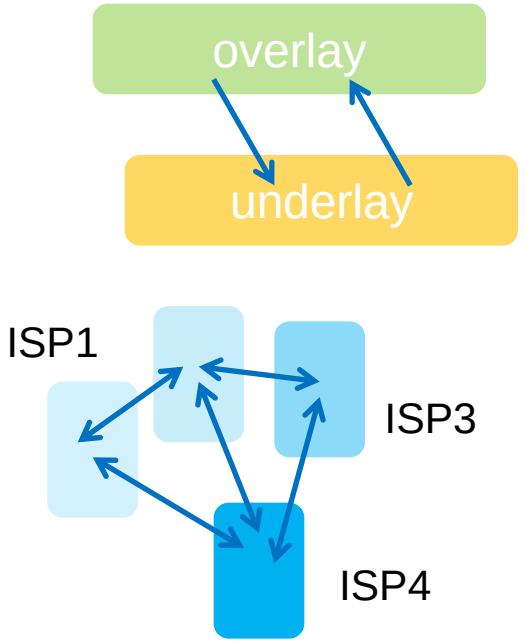
*(proposed by D.Clark *et al*.)

Exchange of Information
between communication end-points

Seed

- *Exchange of information* between end-points of communication
  - If it serves the incentives of stakeholders / if it is beneficial
  - Allow stakholders to express their interests/choices

- *Constituent elements*
  - Abstraction of information
    - Do not expose critical information
  - **Exposure of information**
  - **Collection of information**
  - Assessment of information
  - Decision making



Exchange of Information
between communication end-points

Impact

- Design and deployment of more “open” systems and interfaces
- Anticipate users’ reactions when QoE is unsatisfactory
- Compatible with Information-centric networking

Interaction with other principles

- This is an enabler of Clark’s *et al.* ‘*design for tussle’* principle
- Compatible to the *end-to-end* and *modularization* principles
  - Complexity mostly to reside at the edges – isolation, generality
- Can enable *locality*

Sustain the Investment

***Challenge:* coopetition**

- result of competing antagonistic actions due to conflicting interests between parties / actors
- Negative global return
- Ex. DPI

<u>Objective</u>: Internet to be designed to **sustain brain and resource investment toward a global positive return** (not to sustain detrimental conflicting interests)

Sustain the Investment

Seed

- Sustain the Investment (brain, innovation, resource) toward a global positive return

- Internet should not be ‘designed *for Tussle’* only

  ...but so as to lead to *positive global return*

The question ... of course *"how to determine homogenize user satisfaction, utility functions and individual interests across the entire Internet ?"* ... and address incentives

Sustain the Investment

- In practice
  - Structure Internet design to allow various communities and people's **active involvement** but without impeding its genericity, evolutivity, openness, and accessibility
  - Reward architectural modules and components delivering positive returns – functional module strength -progressively deprecate modules with negative return – weak modules
  - Many ways to model such system ...

Conclusion

Resources Awareness

- Include resources as first order abstractions

Dependability Logic

- Imbue services with attributes of Dependability
- Extend Dependability to include the aspect of Transparency

Exchange of Information

- Exchange of Information for more efficient and beneficial operation

Sustain the Investment

- Design/reward modules that deliver positive global return

- *Many thanks to:*
  - *Francesco Torreli (Eng)*
  - *Massimo Villari (UniMe)*
  - *Dimos Kyriazis (NTUA)*
  - *Andrew Edmonds (Intel)*
  - *Dimitri Papadimitriou (ALBLB)*
  - *George D. Stamoulis (AUEB)*

for their help and input for this presentation!

Thank you for your attention!

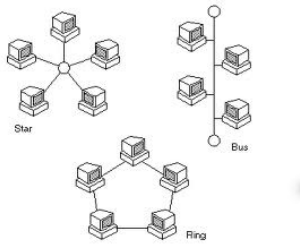
Questions?

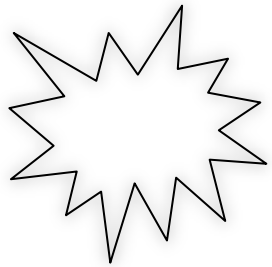
Back-up

Resources Awareness

Challenges

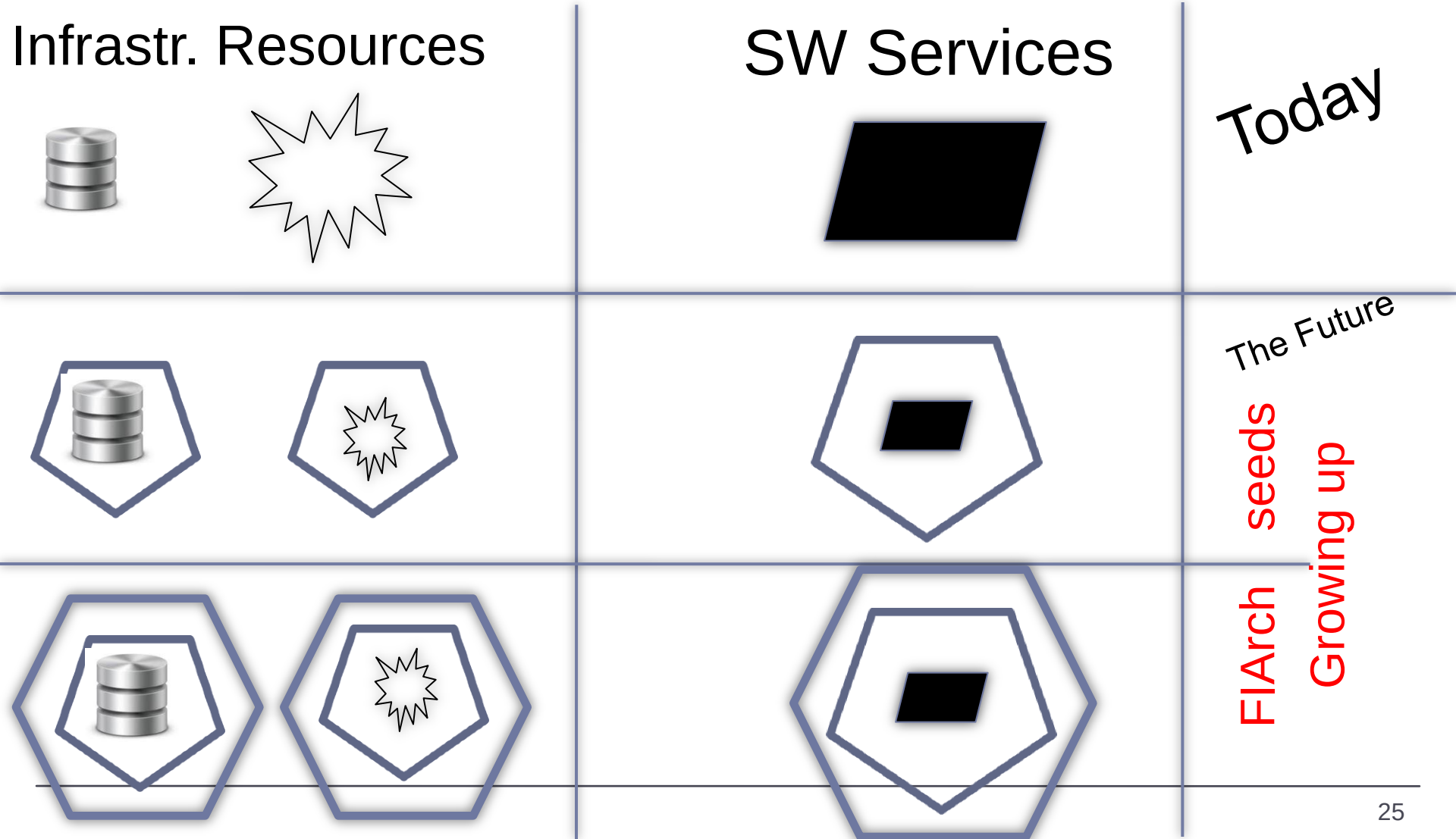
- *Resources* have a physical representation and purpose
- Infrastructure resources:
  - Network
  - Storage
  - Computation
  - Any kind of resource derived from hardware





- Service components
  - E.g., commercial services as black boxes

Resource awareness: for the infrastructure (HW) and software components (SW)



Dependability Logic
Brief Description

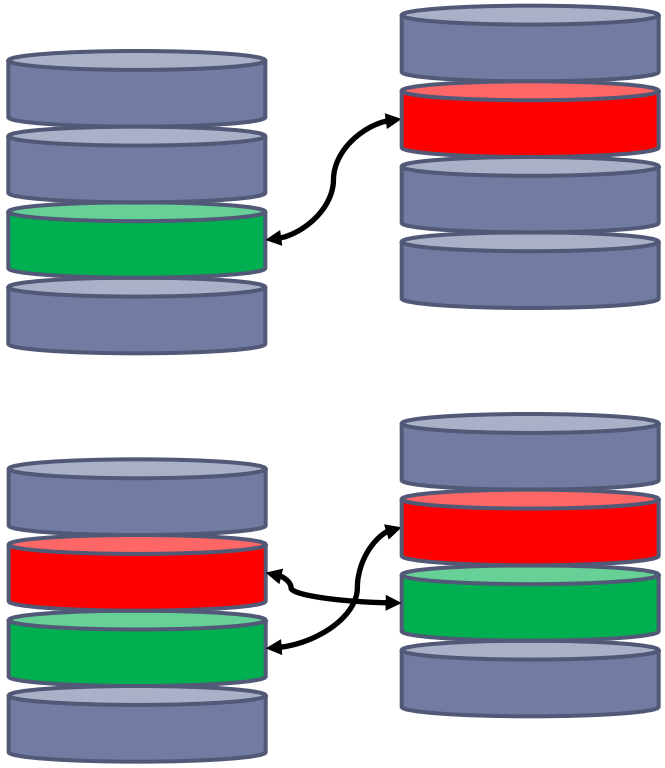
- Defined by 24 years of work by IEEE
- Finalised in 2004
  - Little consideration for the Internet of services, where end-users are **service**- and **not** product-oriented
- The definition should cover **Transparency**

Transparency: the ability to inspect and introspect a service so that the delivered and guaranteed quality of the service agreement can be verified and observed.

End-points of communication

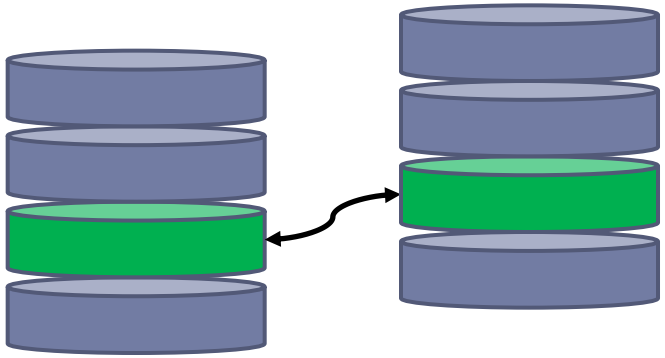
Different layers of different players

e.g., overlay traffic management



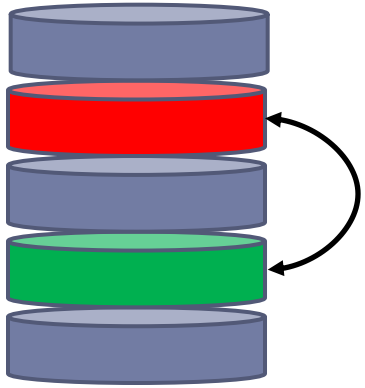
Different players at the same layer

e.g., mTCP, reECN



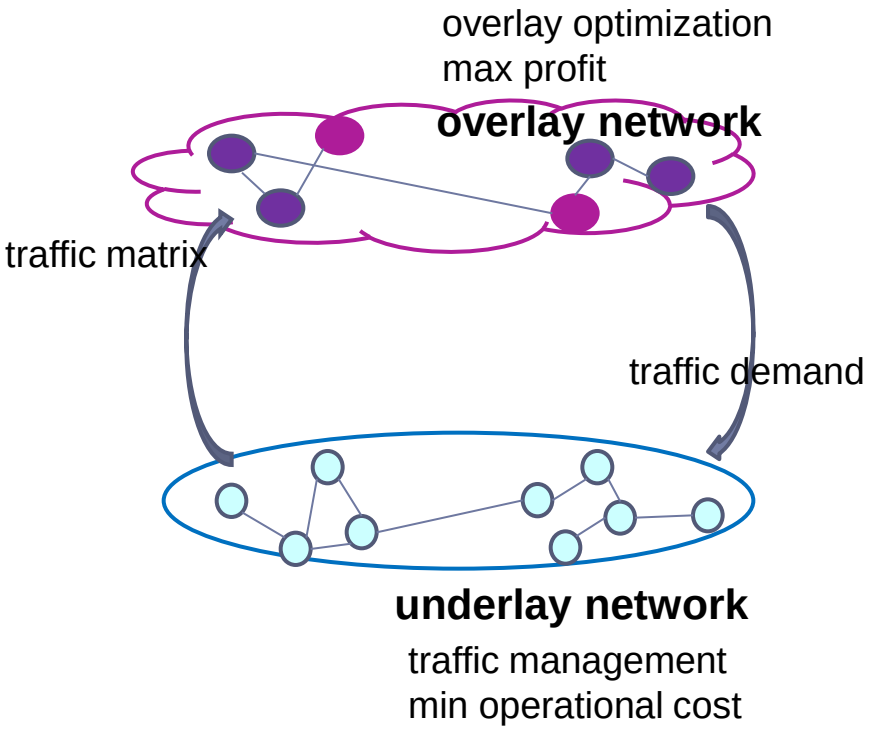
Different layers of the same player

e.g., DPI, mTCP



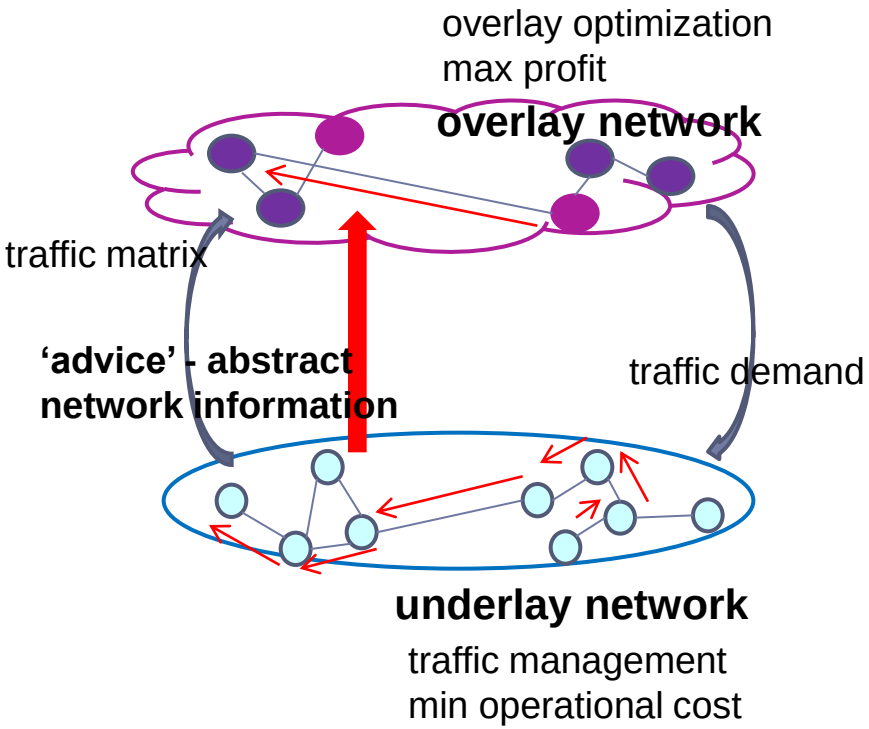
Exchange of Information
between communication end-points

Inter-layer



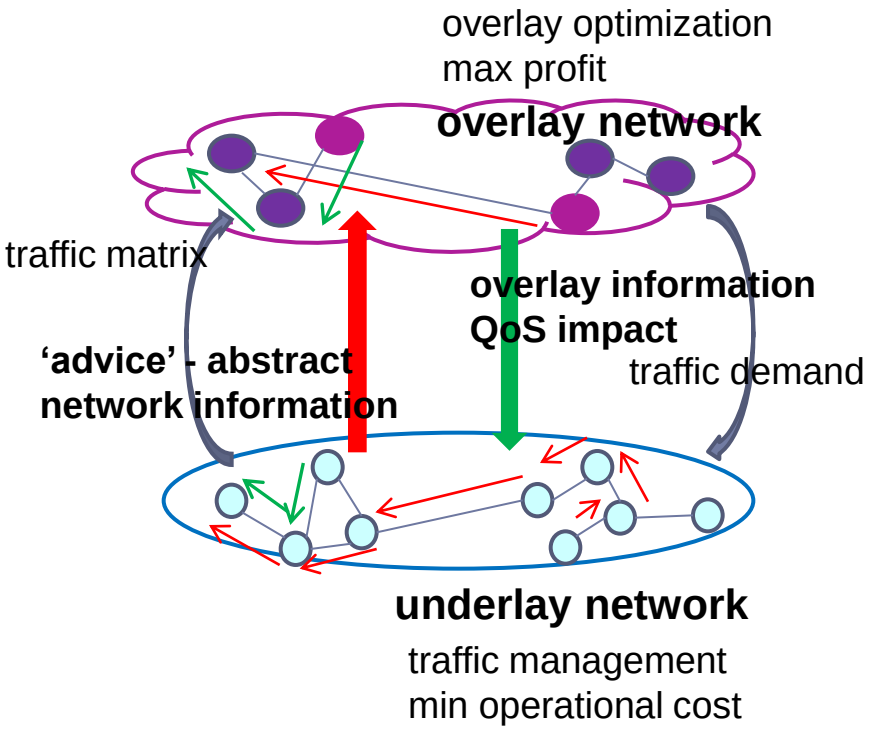
Exchange of Information between communication end-points

Inter-layer



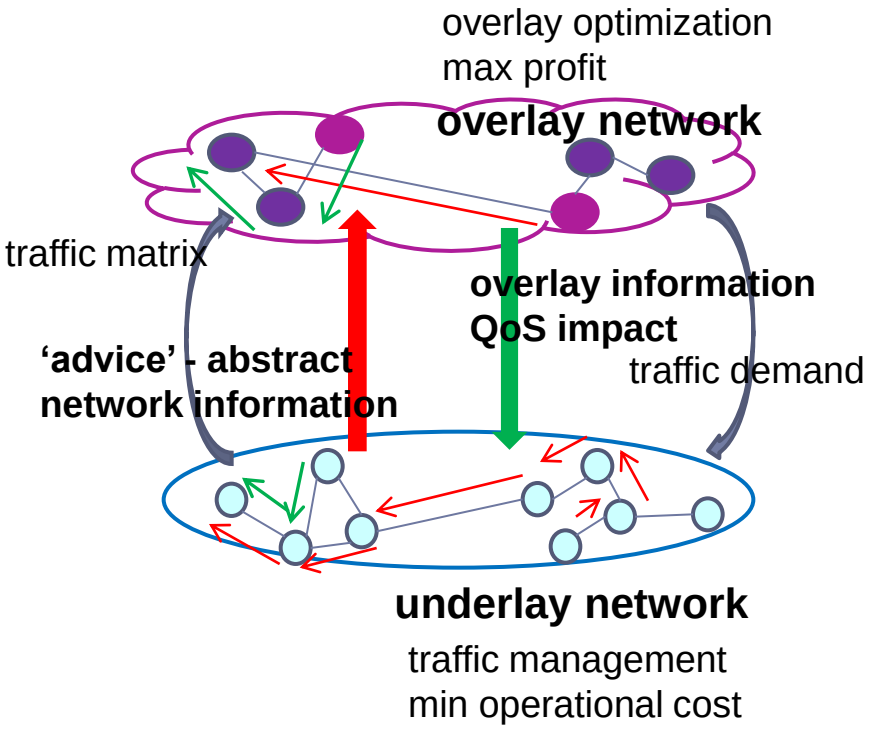
Exchange of Information between communication end-points

Inter-layer

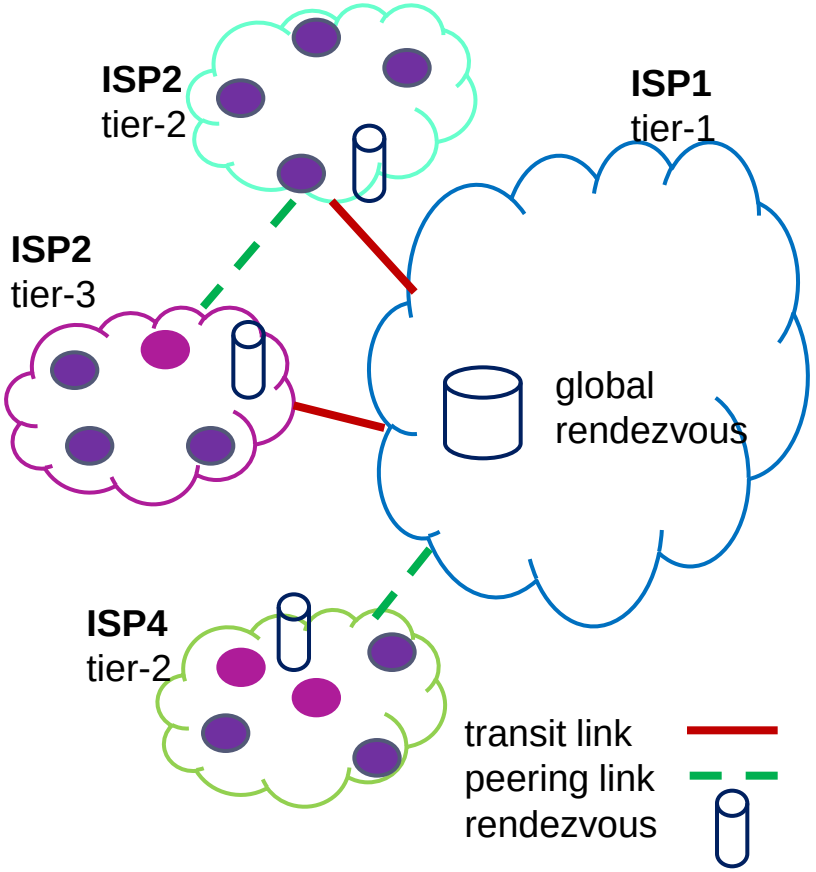


Exchange of Information
between communication end-points

Inter-layer

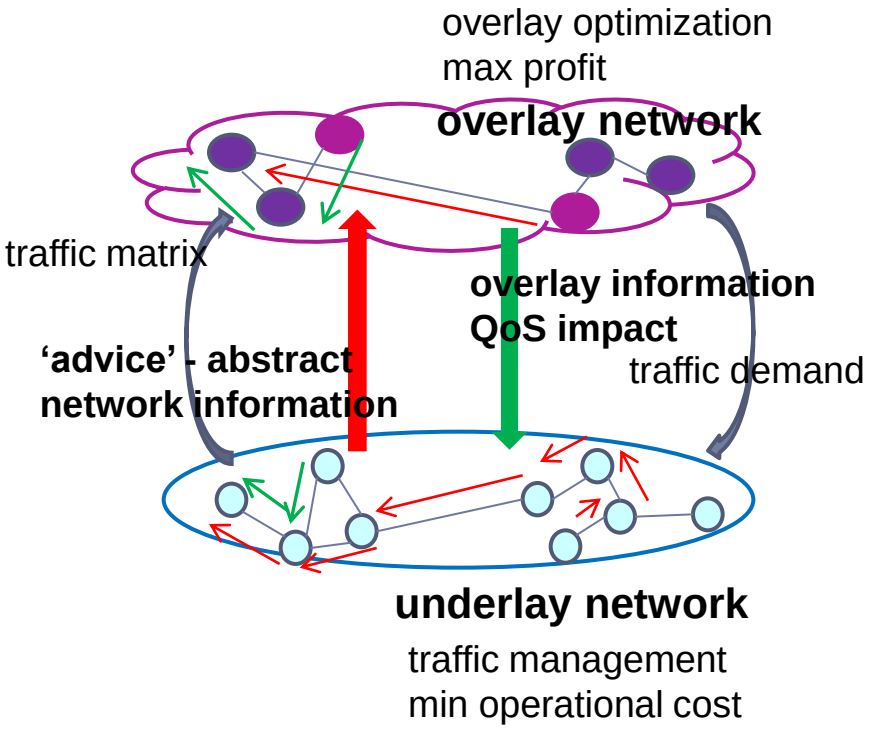


Inter-player

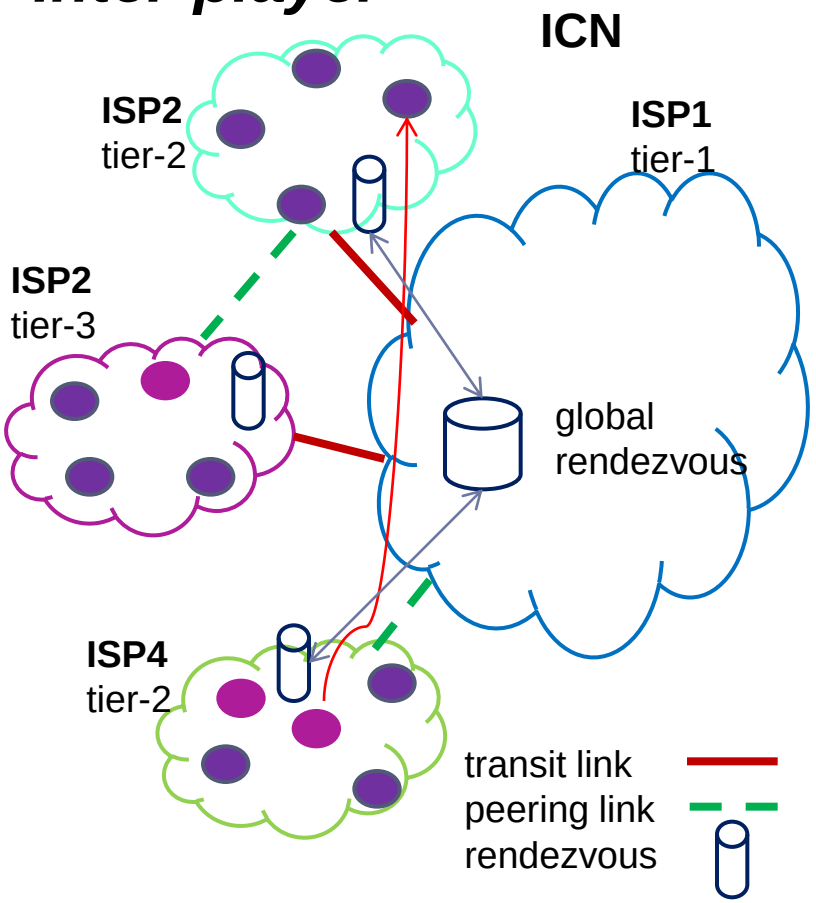


Exchange of Information
between communication end-points

Inter-layer

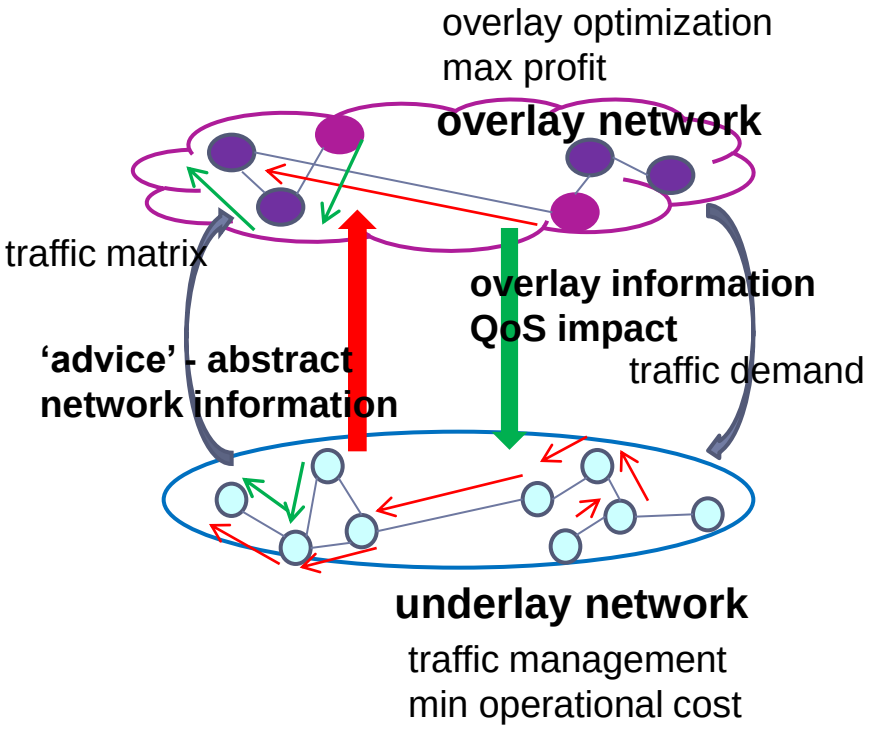


Inter-player

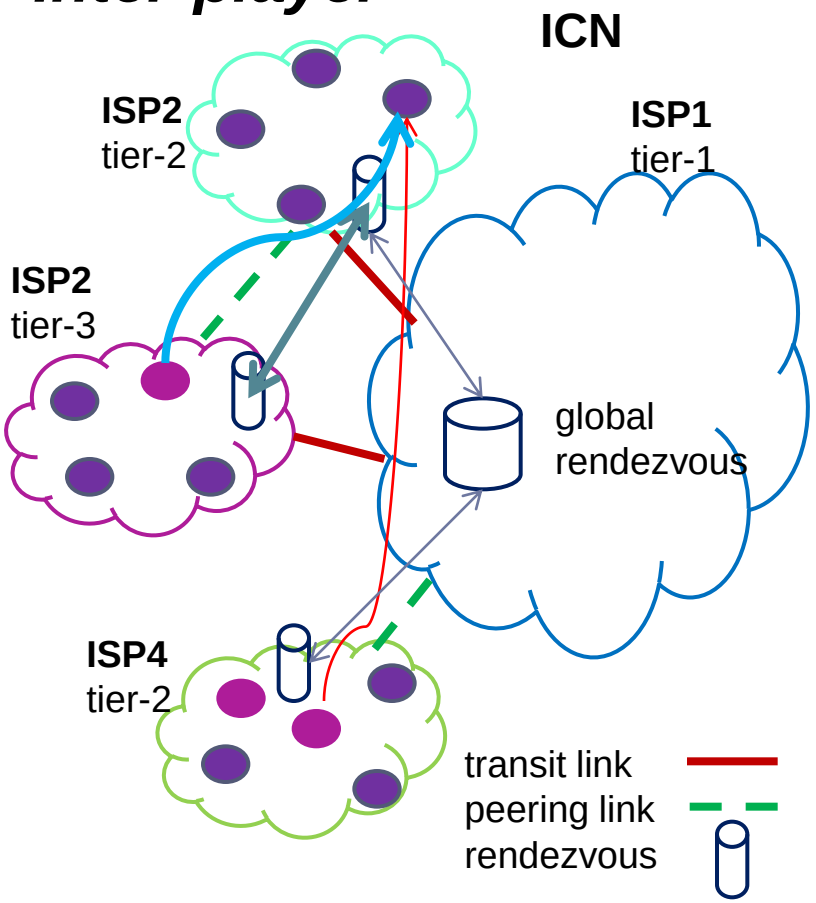


Exchange of Information
between communication end-points

Inter-layer



Inter-player



Applications of the Exchange of Information

- Overlay traffic management
  - The overlay asks underlay for advice on resource selection
- Multipath TCP
  - Congestion information is carried by flows; the end-host makes decision on how to shift load among flows
- Re-ECN
  - Congestion information is made available to any node of the network
- Information-centric Networking (ICN)

No contradiction to the "end-to-end" principle?

Different possibilities for means of information exchange:

- Information is exchanged in packets
  - No impact on routing
- If information is carried in the fields of the protocol headers
  - Limited impact on routing
- Complexity mostly to reside at the edges