Usage of Analytic Hierarchy Process for Communication Service Selection

7th KuVS Workshop on "Future Internet"

Munich, Germany

27th of January 2011

Rahamatullah Khondoker
University of Kaiserslautern
Department of Computer Science
Integrated Communication Systems ICSY
http://www.icsy.de

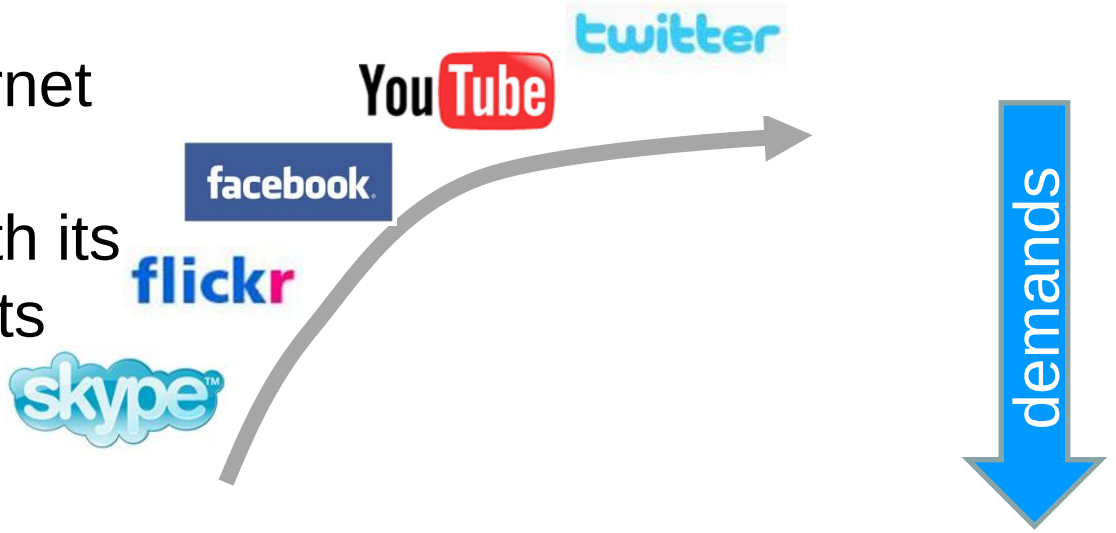
TECHNISCHE UNIVERSITÄT KAISERSLAUTERN

Outline

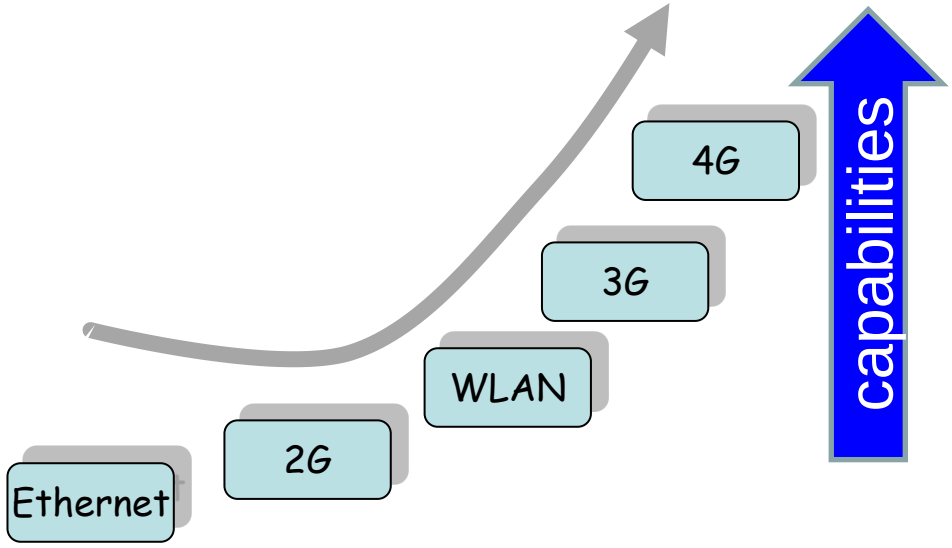
- Motivation
- Description of Requirements and Offerings
- Service Selection
- Conclusion

Motivation

- The number of Internet applications are increasing, each with its specific requirements



- Future networks could evolve by providing a variety of virtual networks



Motivation

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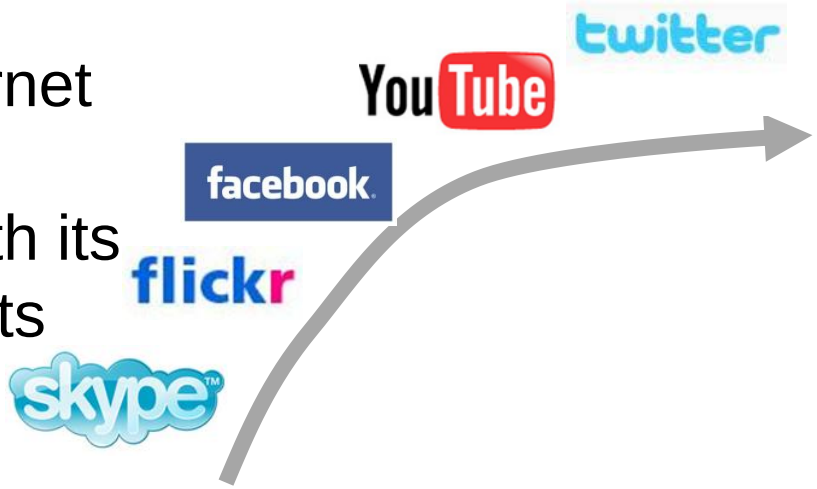
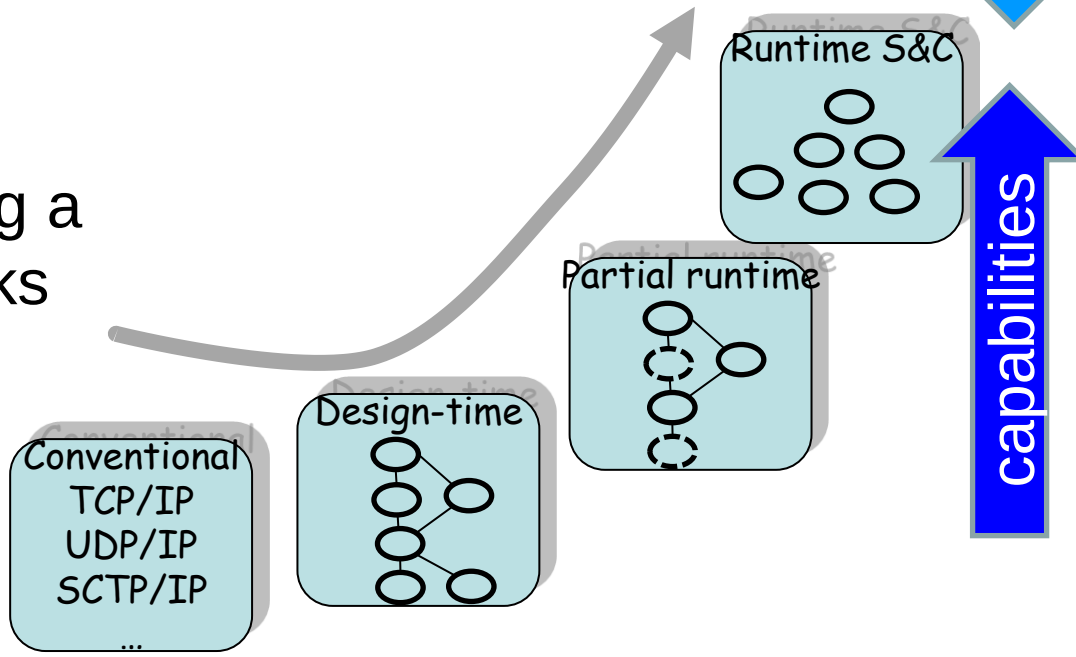


- Future networks could also evolve by providing a variety of protocol stacks



Motivation

- The evolution of the network can be achieved by
  - decoupling applications from the networks, and

    Solution: Description of Requirements and Offerings
  - selecting the best network or protocol automatically based on the application requirements

    Solution: Service Selection

Description of Requirements and Offerings

Communication Service

- A communication service
  - can be seen as a set of visible effects of the underlying implementation of a protocol, mechanism or (virtual) network
  - hides implementation mechanisms

- Examples of effects
  - Reliable transmission
  - Addressing
  - Security
  - Routing
  - Loss Detection
  - Loss Reduction
  - Loop Avoidance
  - Connection Management
  - etc.

Description of Requirements and Offerings

- A Service Description Language (SDL)[Ref. 1] consists of
  - a set of vocabularies (e.g., effect, operator, attribute)
  - a grammar (e.g., an operator connects an effect to an attribute)
- Both application requirements and network offerings can be described by using the construct

$$\{effect\ operator\ attribute\}$$

- The packet loss offering of the TCP/IP protocol stack can be expressed as $packet\ loss = 0\%$
- An administrator constraint can be expressed as $authentication = true$

Ref. 1. R. Khondoker, E. M. Veith, and P. Mueller, “A description language for communication services of future network architectures,” Will be Published in the Proceedings of the Network of Future, Paris, France, 2011.

Description of Requirements and Offerings

- This construct allows the selection process to
  - choose both fine-grained (a protocol) and coarse-grained services (protocol groups, (virtual) networks) in a homogeneous way

    because the same elements/components are used
  - be flexible

    as newly developed services or application requirements can be described
  - select an appropriate service by matching the description of the offered service with the requirement

    as both are described using the same construct

Service Selection

Service Selection Process

- The aim of the selection process is to choose the best service based on given application requirements and the operating environment

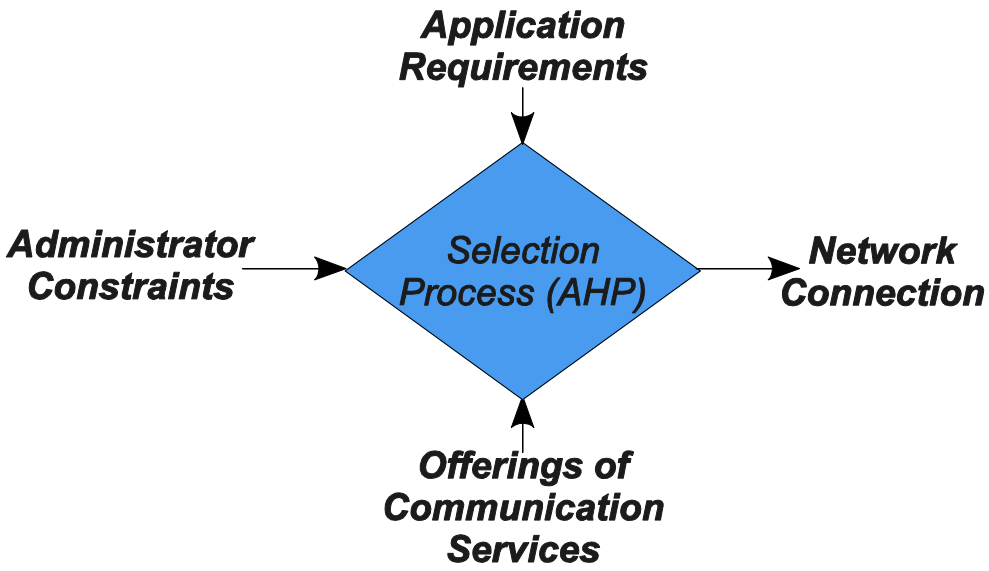


Fig 1. Service Selection Process

Service Selection Process

- Selecting the best service using a single effect such as delay is trivial
- However, communication services have multiple effects which are depedent on each other

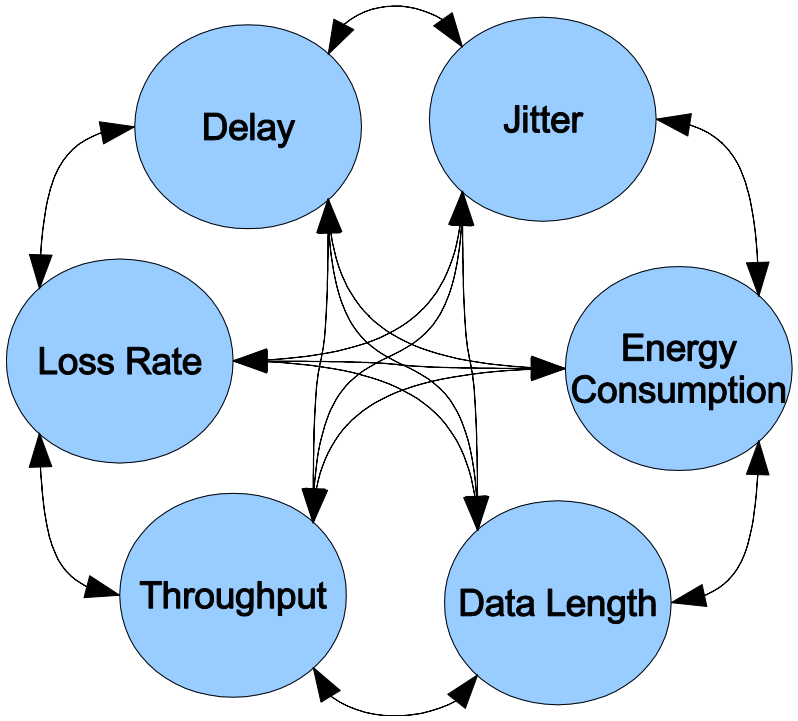


Fig 2. Interdependencies among the effects

Service Selection: Methodology

- Service Selection Methodology
  - Selecting a service by comparing more than one criteria is a multi-criteria decision making problem
  - For solving such a problem, we need Multiple Criteria Decision Analysis (MCDA) methods
    - Several algorithms (MAUT, AHP, ELECTRE III, Evamix) exist for doing this
  - Only AHP allows interdependent criteria [Ref 2]
  - We used Analytic Hierarchy Process (AHP)
    - Checking consistency of evaluation measures
    - Reduces biased behavior in decision making process
  - AHP must be adapted for automatic service selection

Ref. 2. A. de Montis, P. D. Toro, B. Droste-Franke, I. Omann, and S. Stagl, “Assessing the quality of different mcda methods,” 2000.

Service Selection: AHP

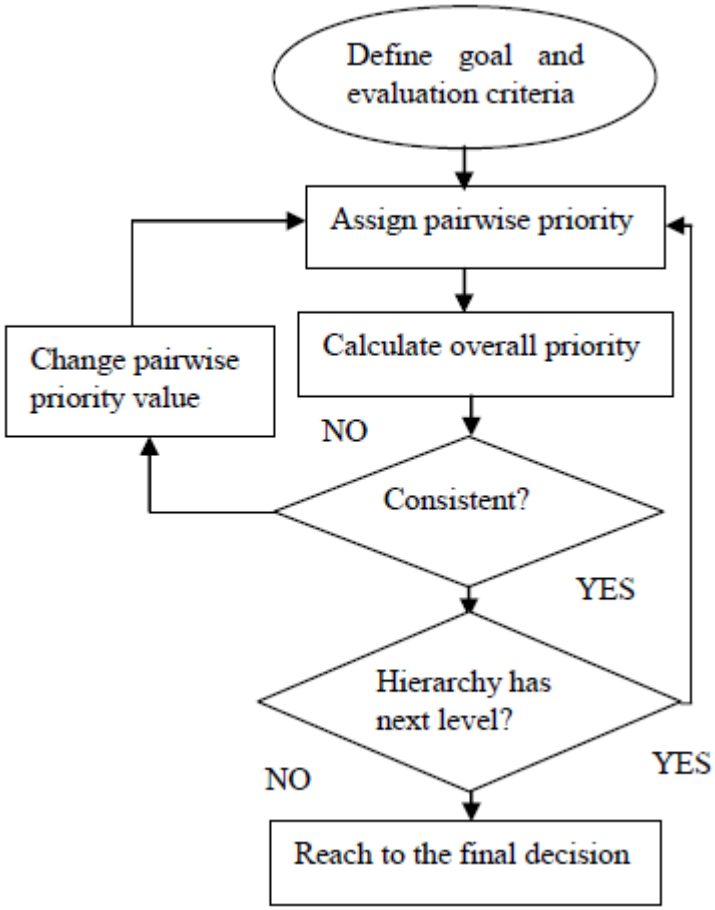


Fig. Analytic Hierarchy Process (AHP)

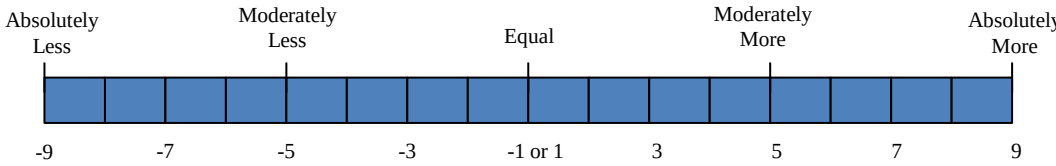


Fig. Pairwise comparison scale

Service Selection: Usage of AHP

- AHP in service description and selection
  - Input
    - A set of effects
  - Requirements
    - Pairwise priority assignment
    - Calculate one priority for each effect
  - Offers
    - Pairwise priority assignment
      - This requires a mapping mechanism which cannot be done by AHP
    - Calculate one priority for each effect
  - Output
    - A service with the highest priority value

Service Selection

- The priority assigned in requirements needs to be mapped to the offered services
- Pairwise prioritization of services per effect
  - The mapping must be generic
  - The mapping should be monotonic
  - An approach for mapping is proposed to use monotonic interpolation/extrapolation

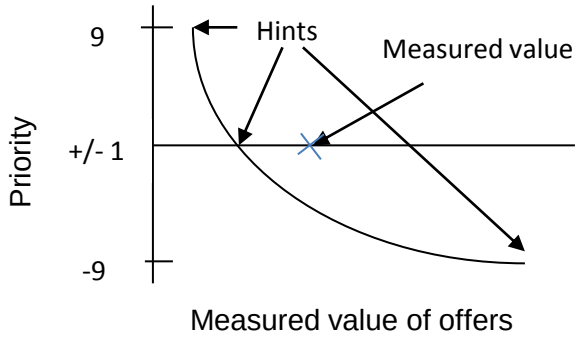
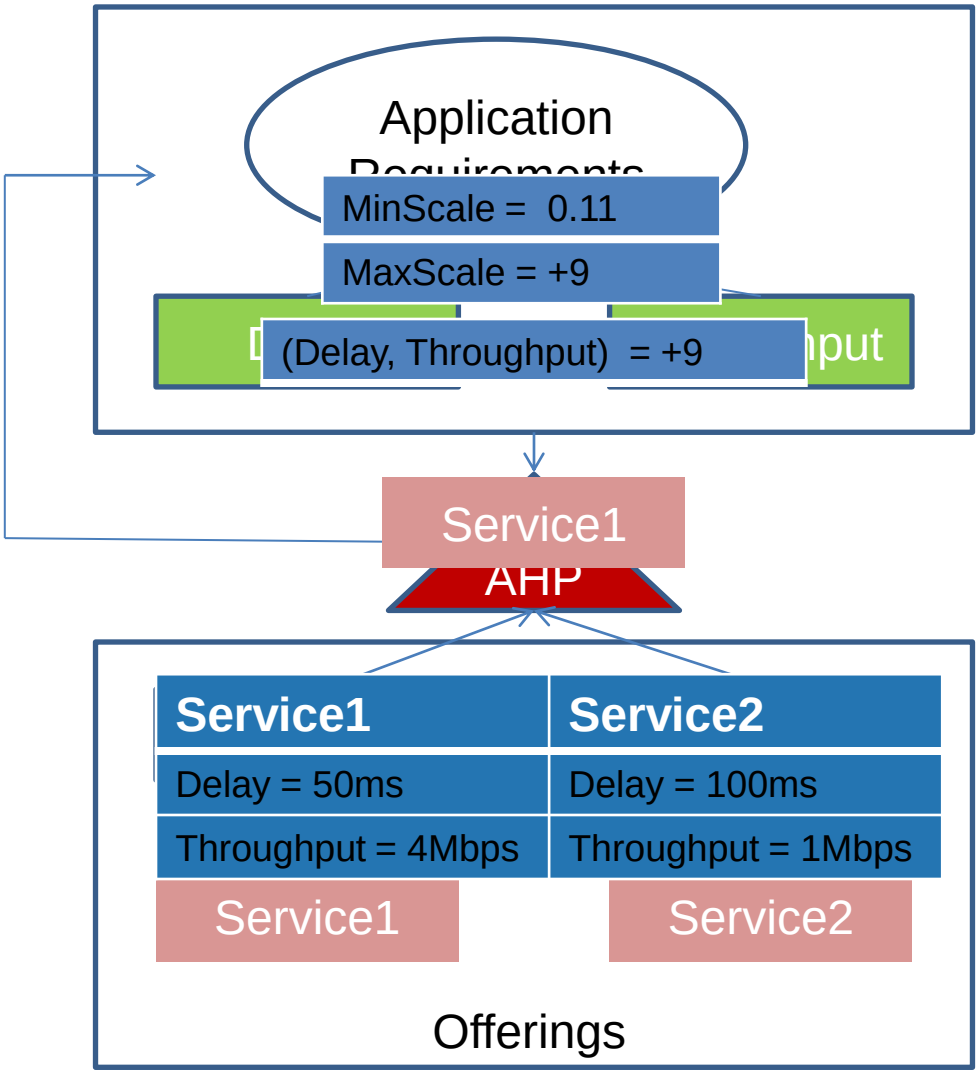


Fig. Values in terms of hints

Example: AHP in Service Selection



Results of Service Selection

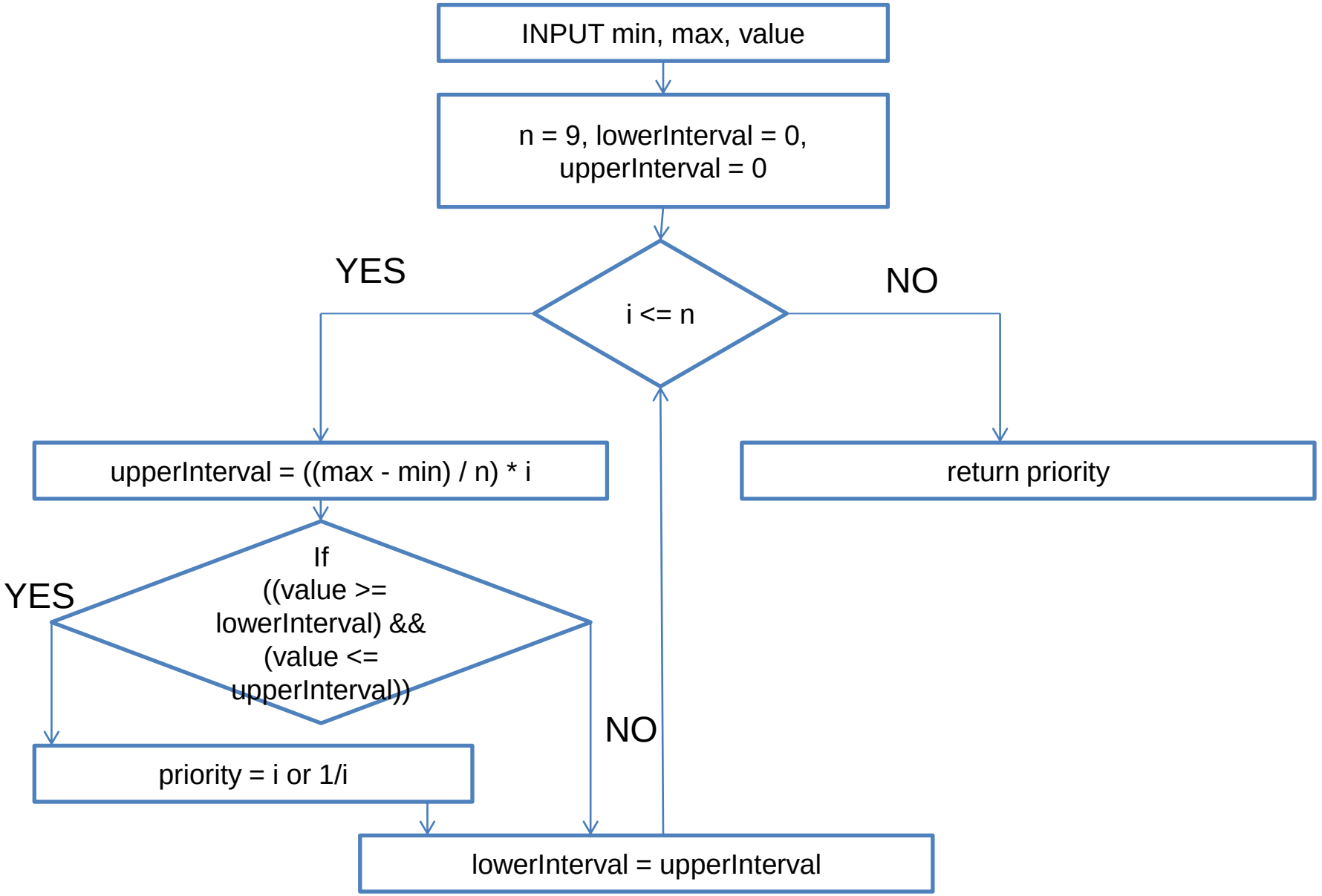
- Priorities assigned for selection criteria

Delay	Throughput	Jitter	Loss ratio	Energy Consumption	Data length
1	5	9	5	9	5
0.2	1	1	2	1	1
0.11	1	1	1	1	1
0.2	0.5	1	1	2	5
0.11	1	1	0.5	1	1
0.2	1	1	0.2	1	1

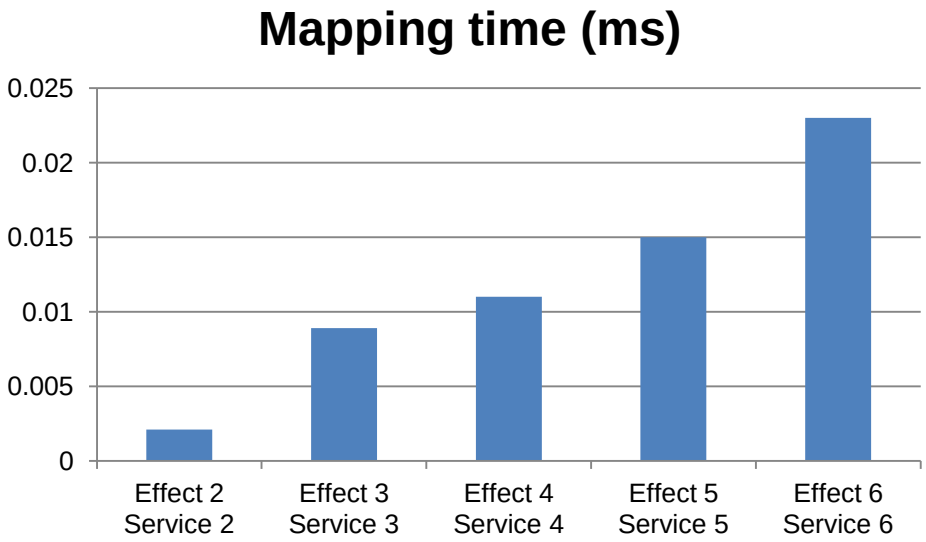
- Values for service offerings

Effects	S1	S2	S3	S4	S5	S6
Delay	10	50	250	200	220	260
Throughput	1	2	10	12	15	32
Jitter	1	2	10	15	17	20
Loss ratio	2	4	5	8	10	15
Energy Consumption	10	50	40	70	120	100
Data length	1500	500	600	1400	700	1000

Priority assignment algorithm

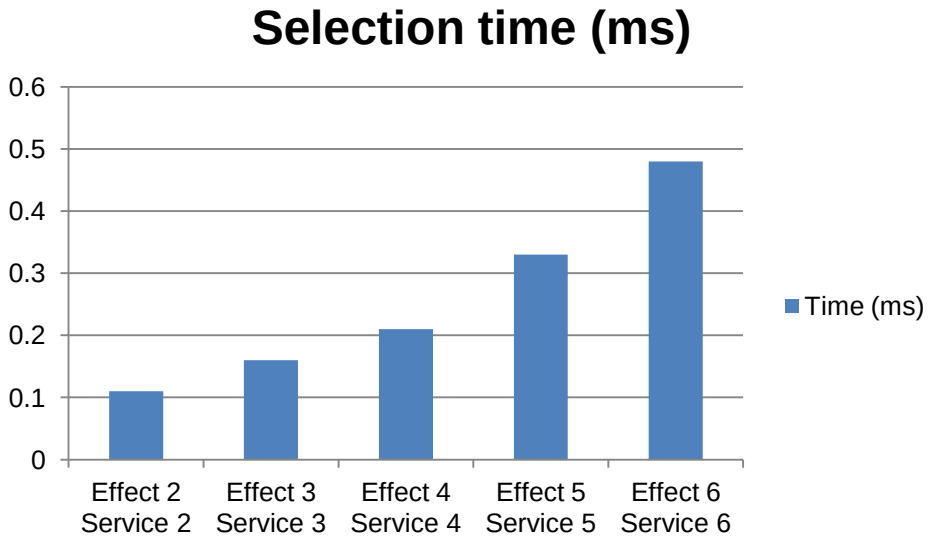


Results of Service Selection



- Mapping time is linearly increased
- Maximum 0.023 ms is required for mapping

- Selection time is exponentially increased
- Maximum 0.48 ms is required for selecting the best service using 6 selection criteria

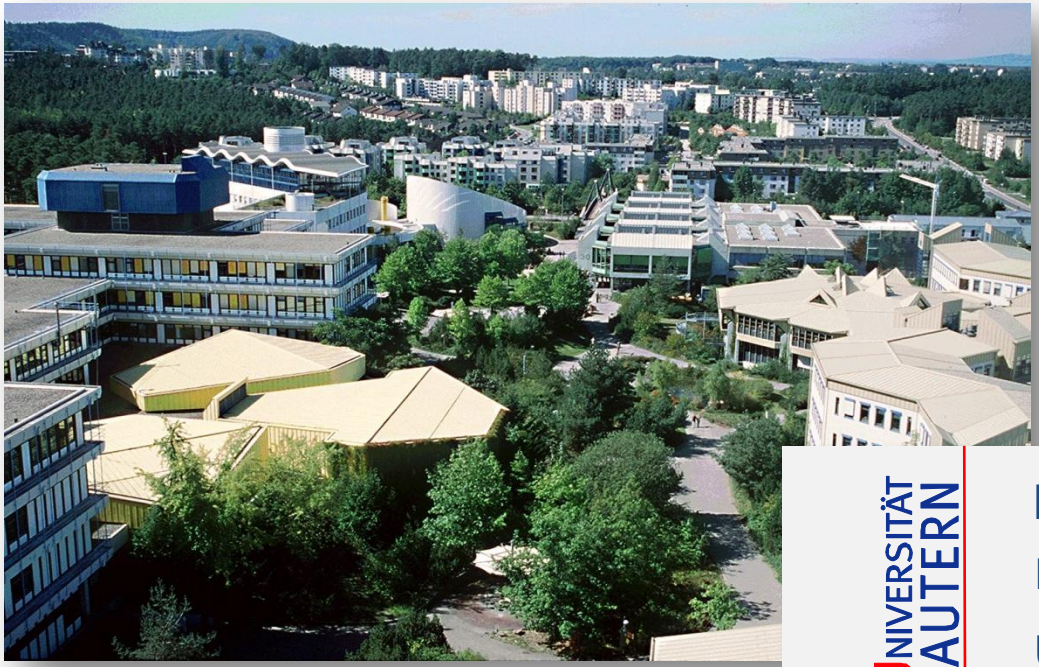


Summary and Outlook

- Applications use the network differently, therefore they have different network requirements
- At the same time, networking capabilities and protocols make advances
- We have seen how applications can make use of advancing network capabilities
- Describing requirements and offerings
  - Supports the parallel development of both applications and communication services
  - supports evolution of the Internet
- Service selection process
  - can use the protocols as soon as they emerge

Thanks for your attention

Any questions, comments or concerns?



M. Rahamatullah Khondoker, M.Sc.

Integrated Communication Systems ICSY

University of Kaiserslautern
Department of Computer Science
P.O. Box 3049
D-67653 Kaiserslautern

Phone: +49 (0)631 205-26 43
Fax: +49 (0)631 205-30 56

Email: khondoker@informatik.uni-kl.de
Internet: http://www.icsy.de