Aalto University
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Socioeconomics of diffusion of Internet protocols

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Agenda

- Socio-economic cross-issue in the FI program
- Motivation for standards adoption research
- Research question & scope
- Protocol development process
- Protocol adoption models
- Case 1: Multipath TCP
- Case 2: Host Identity Protocol

Socio-economic cross-issue in the FI program (2008-2012)

- General approach: Analyze economic potential and feasibility of technologies developed by the technical WPs
- Contributions mainly from Aalto/Comnet
- List of topics
  - Future Internet Scenarios (Program strategy)
  - Two-sidedness of Internet content delivery (WP3)
  - Adoption barriers of Host Identity Protocol (WP1 / WP2)
  - Modeling the value of end-to-end multipath protocols (WP1)
  - Survey of content provider multihoming and load balancing (WP1)
  - Economic feasibility of a wide-area multihoming solution (WP1)

Motivation for protocol adoption research

Increasing and diversifying usage of Internet questions the capability of Internet to scale

Need for new solutions, including protocols

Vast amount of Internet protocols is being developed and standardized by the IETF…

…but only few of them gets widely adopted. WHY?

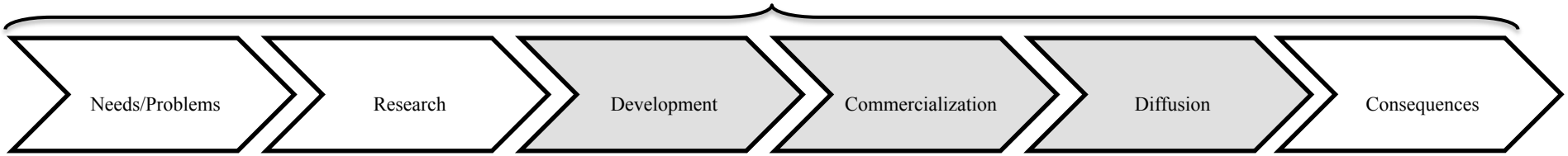
Research question and scope

- *How do stakeholders' incentives and relationships (i.e., value networks) impact protocol diffusion, and what strategies can be used to facilitate protocol adoption?*

- Scope
  - Internet as an environment for innovation diffusion
  - IETF protocols on application, transport, and Internet layers
  - Focus on multi-stakeholder, inter-domain adoption scenarios
  - Adoption as a process:
    development/standardization → commercialization → diffusion

Protocol development process

Rogers' innovation development process



Protocol development process

1. Development

- Deployable design following design principles
- Standardization including a reference implementation
- Key stakeholders: Research community (academia and company R&D)

2. Commercialization

- Implementation
- Gradual introduction to the market
- Key stakeholders: device/OS/ application vendors, open source software developers

3. Diffusion

- Deployment
- Multiple adoption models
- Key stakeholders: end-users (consumers, content providers, ISPs etc.) and device/OS/application vendors

Warma H., Levä T., Tripp H., Ford A., Kostopoulos A. (2011). **Dynamics of Communication Protocol Diffusion: the Case of Multipath TCP**. *Netnomics, vol. 12, nr. 2, pp. 133-159.*

Protocol adoption models

	Unintentional adoption	Indirect adoption (intentional)	Direct adoption (intentional)
Adoption route	Device acquisitions and OS updates (either full update or OS patch) including the protocol	Acquisition of a service application including the protocol	Acquisition of the protocol support by updating the device or its software
Driver of the adoption	Updating the software due to other reasons (the protocol does not matter at all in adoption decision)	Adopter perceives benefits of using a service but may not be aware of the source causing them	Adopter perceives benefits of using the protocol and links these benefits to the protocol
Key decision and decision-maker	*Device / OS vendor* enables the protocol by default in its products	*Application service provider* takes the protocol into use in in its software	*Adopter itself* acquires the protocol support by updating her device
Adopter's awareness of the innovation	No awareness (or user is indifferent to the protocol and its benefits)	Partial awareness (user knows the benefits of the protocol)	Full awareness
Example from the MPTCP case	MPTCP comes with the OS update	MPTCP would be added to the latest version of uTorrent	Adopter installs the MPTCP patch from the OS support site

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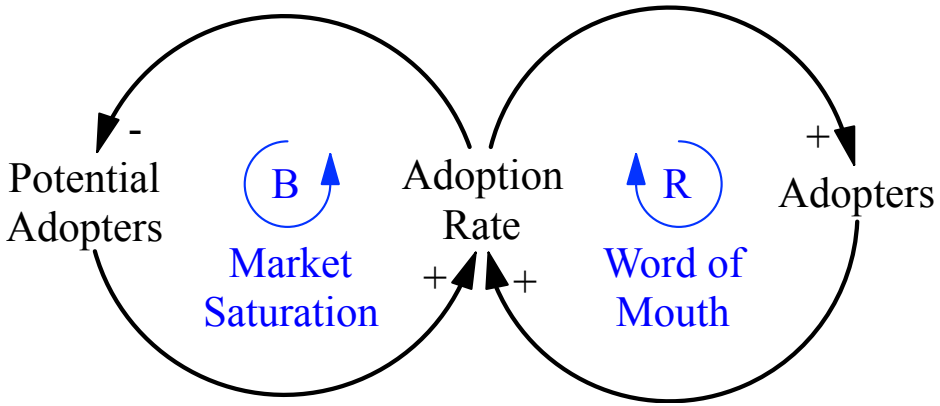
Case 1 – MPTCP:

Dynamics of Multipath TCP adoption

- Multipath TCP
  - Splits the traffic of one TCP connection into multiple subflows
  - Increases throughput and resilience, enables seamless handovers
- Objective: to understand the dynamics of protocol diffusion
  - Cross-side network effects between content providers and consumers
- Method: System dynamics
  - An approach to understand behavior of complex systems over time



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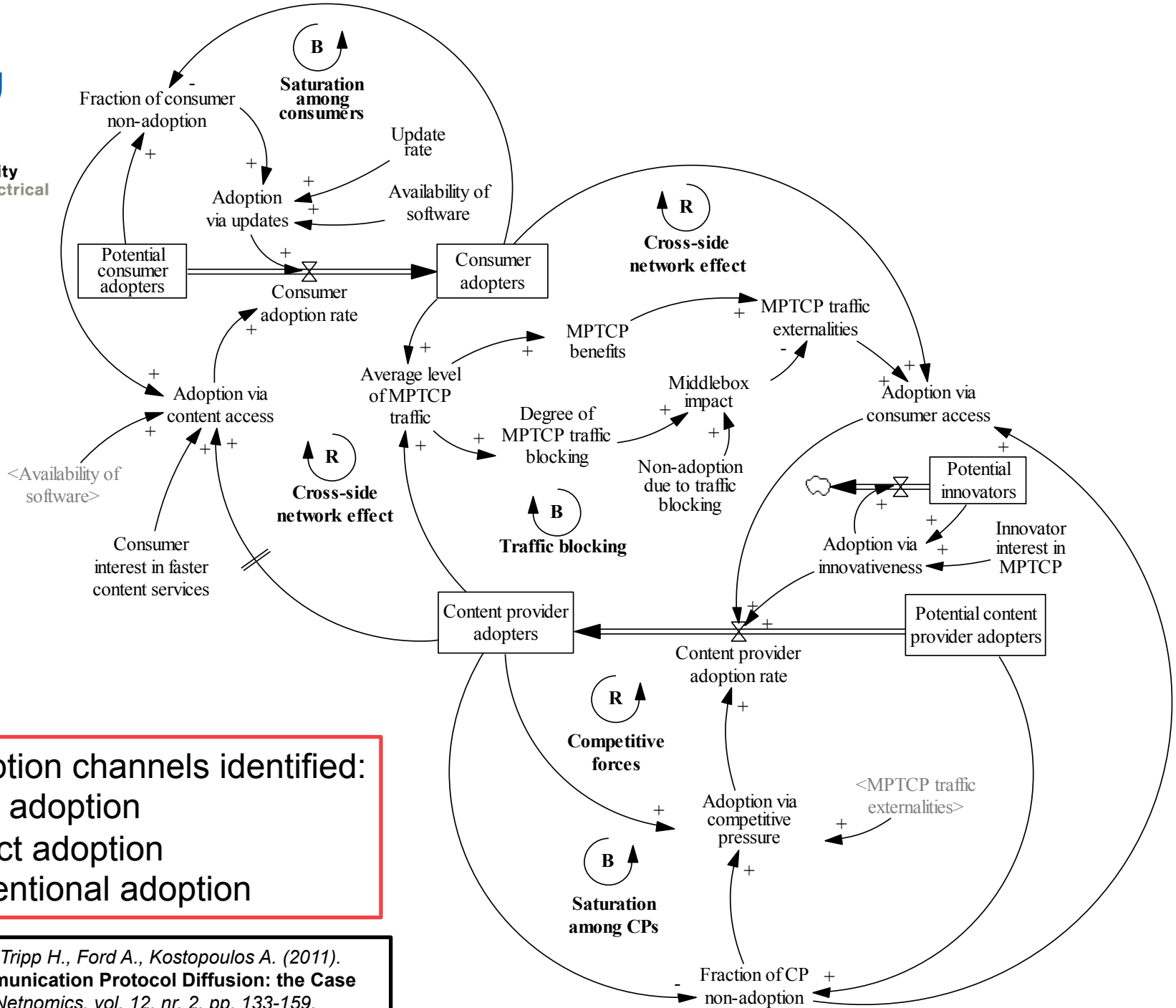

Three adoption channels identified:

1. Direct adoption
2. Indirect adoption
3. Unintentional adoption

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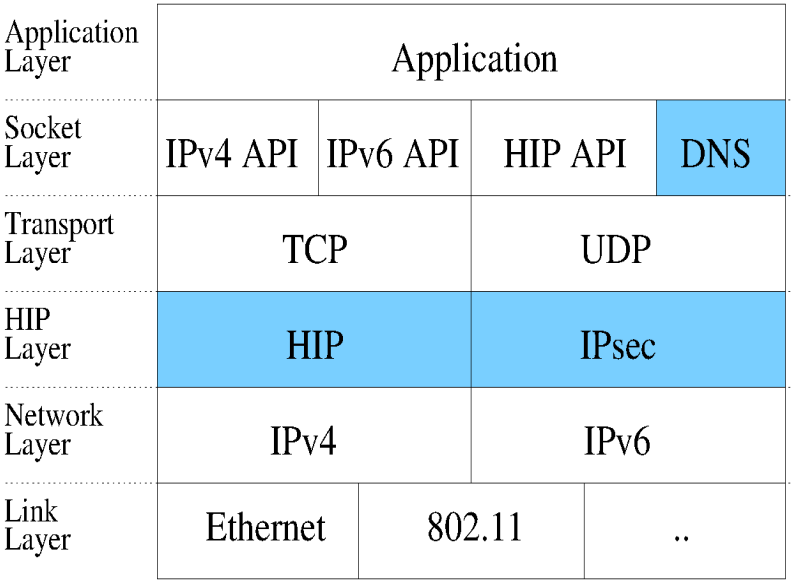
Case 2 – HIP:

Adoption barriers of Host Identity Protocol

- Host Identity Protocol
  - Loc/ID split protocol introducing host identity namespace based on cryptographic identifiers
  - Improves security, mobility, NAT traversal and IPv6 interoperability
  - Developed since 1999
  - Adoption minimal



- Research question: Why has HIP not been widely adopted yet?
- Research method: 19 expert interviews (45-100 min)

Levä T., Komu M., Keränen A., Luukkainen S. (2012). **Adoption Barriers of Network-layer Protocols: the Case of Host Identity Protocol**. *Submittet to Computer Networks (Elsevier).*

Case 2 – HIP:

Reasons for non-adoption

1) Demand for the functionalities of HIP has been low.

Where demand has existed, substitutes have been favored because:

2) Substitutes were earlier in the market,
3) Substitutes have relative advantage due to some design choices of HIP,
4) Lack of early adopter benefits requires costly coordination,
5) People have misconceptions about HIP, and
6) Research-mindedness of HIP developers has lead to strategic mistakes.

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Case 2 – HIP:

Strategies to foster adoption of HIP

- External event to trigger
  - Increasing mobility & multihoming make HIP more relevant
- Focus on the most promising business case
  - Private, single-stakeholder, deployment scenarios
  - Military, public safety, industrial control systems, sensors
- Improve robustness and ease of use of implementations
  - Too much required from academic funding
- Co-deploy HIP with an application or as a library
- Improve people's awareness of HIP
  - Some parts of HIP could be re-used in other protocols

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Summary

- When studying diffusion, also standardization and commercialization steps need to be understood
- Unintentional and indirect adoption by end-users are important adoption channels for protocols
  - Adoption decisions of OS/application vendors more important
- Cross-side network effects between different adopter groups affect significantly on adoption
  - MPTCP: CP adoption has bigger impact than consumer adoption
- HIP not adopted due to limited demand and (perceived) relative disadvantage compared to substitutes
  - Design choices and people's misconceptions affect