



# Implementing the Future Internet: A Case Study of Service Discovery using Pub/Sub in the ANA Framework

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The **ANA** Project -  
**A**utonomic **N**etwork **A**rchitecture

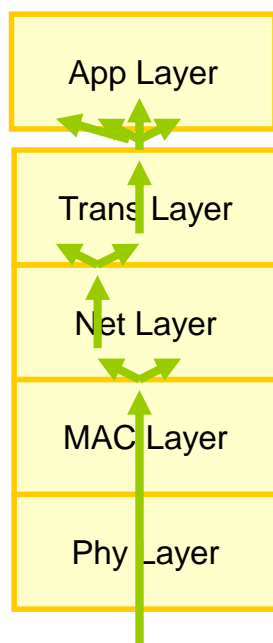
## Outline

- Autonomic Network Architecture (ANA)
  - From Layers to Functional Composition
  - Network Abstractions
- Case Study
  - Field Based Service Discovery (FBSD)
  - FBSD implementation in ANA
- Conclusions

## Motivation

- ANA stands for Autonomic Network Architecture
  - With a focus on a future Internet architecture
- ANA in a blink:
  - Network must scale in size and in functionality.
  - ANA = framework for function (re-)composition.
  - Dynamic adaptation and re-organization of network.
- Prototype used as feedback to refine architectural models.
- Field Based Service Discovery
  - Address services instead of nodes
  - Anycast routing
  - IP independent

## From Layers to Functional Composition



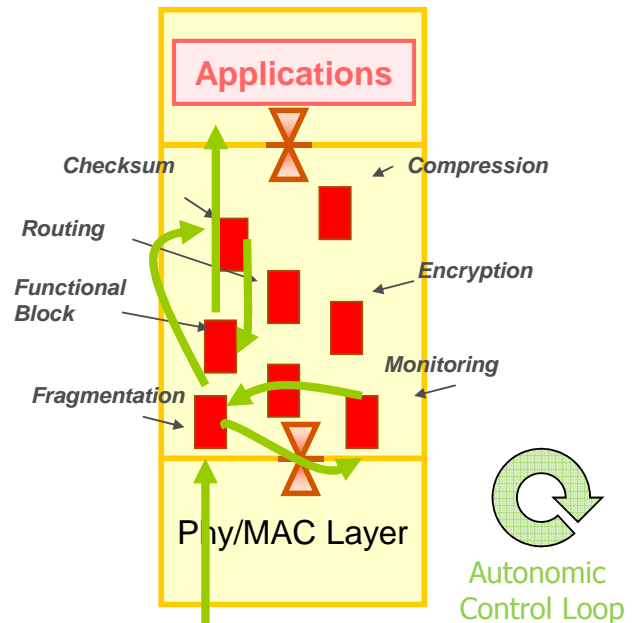
- Port number determines application
- UDP/TCP handling
- IP does defragmentation, checksum,...
- All packets from Ethernet with:
  - 0x0800 → IP
  - 0x86DD → IPv6
  - 0x0806 → ARP
  - 0x809B → Apple Talk

## From Layers to Functional Composition

- At least same functionality as before, but **decomposed**
- Allows for composition of functionality

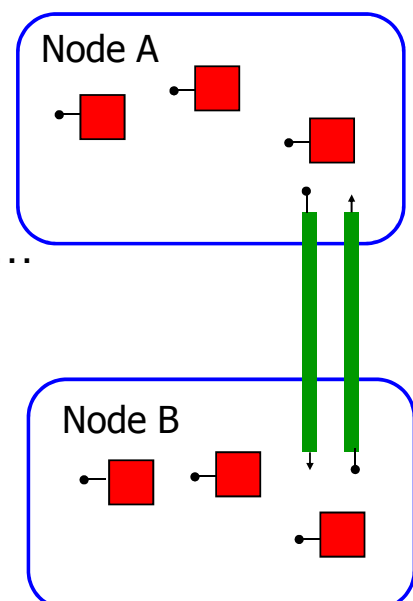
Also:

- New functionality integrated in protocol stack
- **Dynamic re-configuration**
- **Autonomic properties**



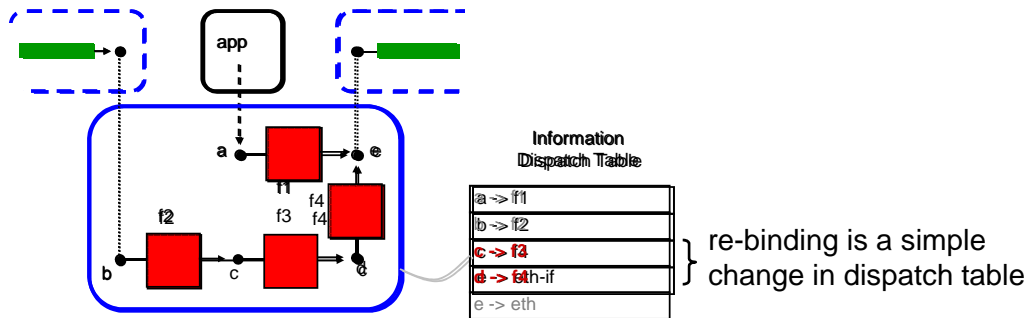
## Network Abstractions

- **Functional Block (FB)**
  - Module implementing protocol or other **functionality**
  - E.g., Protocol framing, encryption, ...
- **Information Channel (IC)**
  - Abstraction of **communication channel** with distant node
- **Information Dispatch Point (IDP)**
  - Addresses FB or IC
  - Similar to **pointer**



## Functional Composition

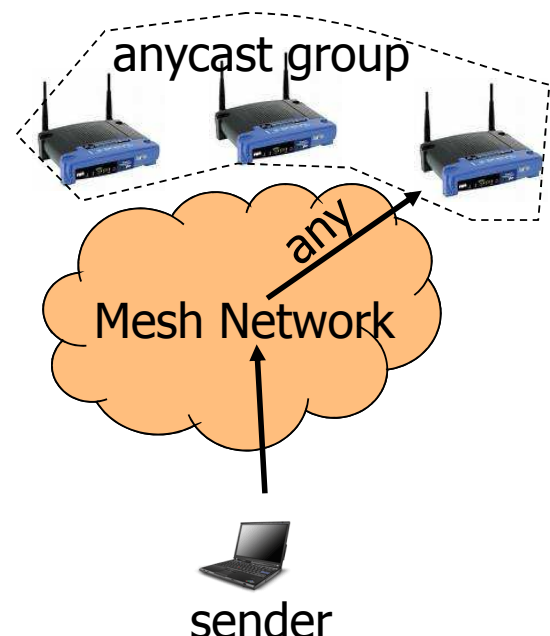
- "Chains" of functions are setup on-demand in a dynamic way.
  - Packet dispatching in ANA is based on IDPs.



- re-binding of IDP 'c' is not visible to users of 'c' (function f2 here)

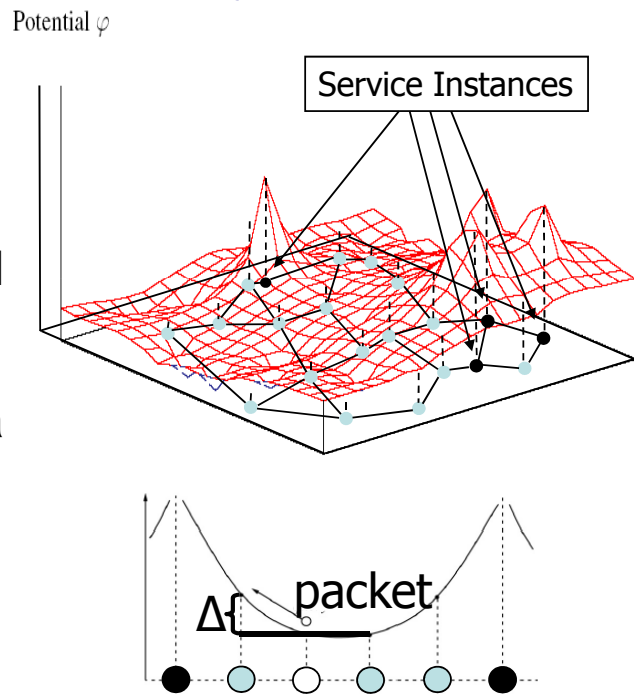
## Field Based Service Discovery (Pub/Sub)

- IP is **address centric**, i.e., identification of nodes
  - Future networks should be **service centric** and leave it up to the network to decide where the service is provided
- use **anycast routing** for service discovery



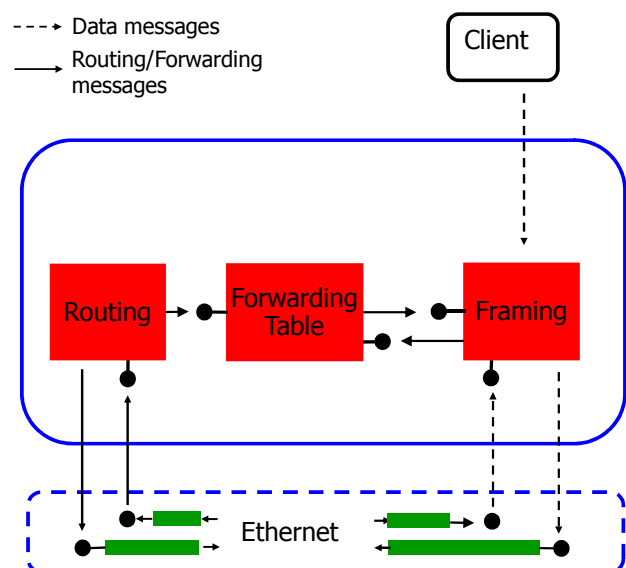
## Field Based Service Discovery

- Based on potential fields from physics (e.g., electrical field, gravitation field)
- One field per published service
- Potential value decreases the farther a node is to service instance
- Routing along the **steepest gradient**



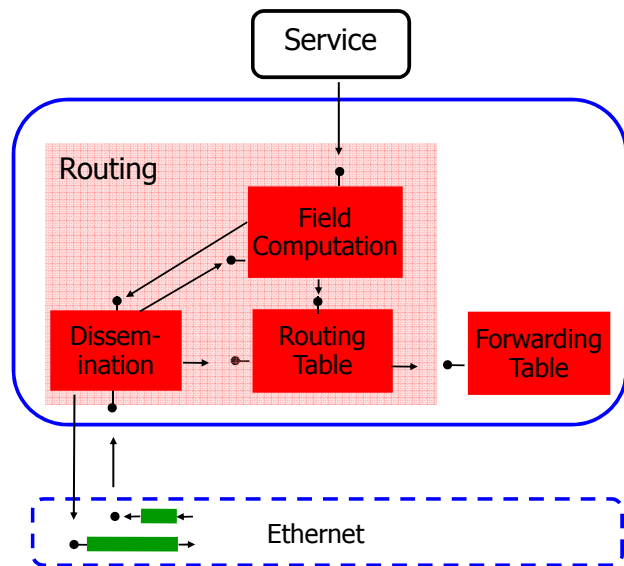
## FBSD in ANA

- Decomposition in
  - Encoding/framing
  - Routing
  - Forwarding
- FBs can be **exchanged independently**
- Message forwarded over Ethernet or Link-Layer directly
  - Non-IP, works with **arbitrary framing**



## Routing Process

- Decomposition of the routing process in
  - Dissemination of routing messages
  - Field computation
  - Routing table
- Dynamic adaption of field function possible



## Conclusions

- ANA Framework
  - Functional composition instead of static layering
  - (Re-)compose protocol stack at runtime
  - Public release: July 2008
  - One possible platform for future internet
  - It's simple and it works: Use it!
- Field Based Service Discovery
  - Anycast routing to address services instead of nodes
  - Decomposable in exchangeable modules
  - Example of non-IP protocol

Thanks! Questions?

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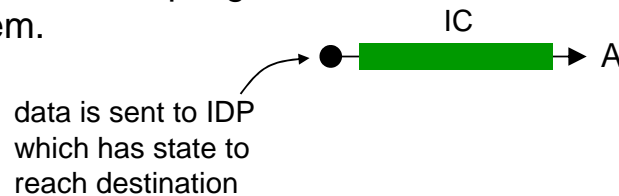
Martin May

## ANA: finding the least common denominator

- Pitfalls in network architecture design:
  - Static/rigid standards instead of mechanisms for change management
  - Built-in address dependency (i.e., **address-centric architecture**)
  - Global address space (requires uniqueness and global coordination)
  - Leaking of and relying on network internal details
- ANA abstractions (to be detailed in the following slides):
  - Information Channel (IC).
  - Information Dispatch Point (IDP).
  - Functional Block (FB).
  - Compartment.

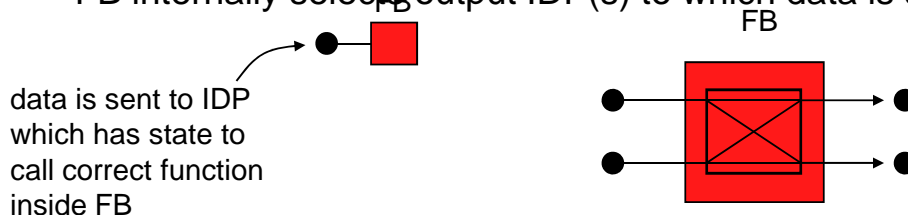
## Information dispatch points (IDPs)

- Startpoint instead of endpoints.
- In ANA communication is always towards a startpoint, or information dispatch point (IDP).
  - Ability to bind to destinations in an address agnostic way.
  - Important to support many flavors of compartments that may use different types of addresses and names.
  - Useful decoupling between identifiers and means to address them.



## Functional blocks (FBs)

- Code and state that can process data packets
- Functional Blocks implement network services
  - Protocols and algorithms are represented as FBs.
  - Access to FBs is also via information dispatch points (IDPs).
  - FBs can have multiple input and output IDPs.
  - FB internally selects output IDP(s) to which data is sent.



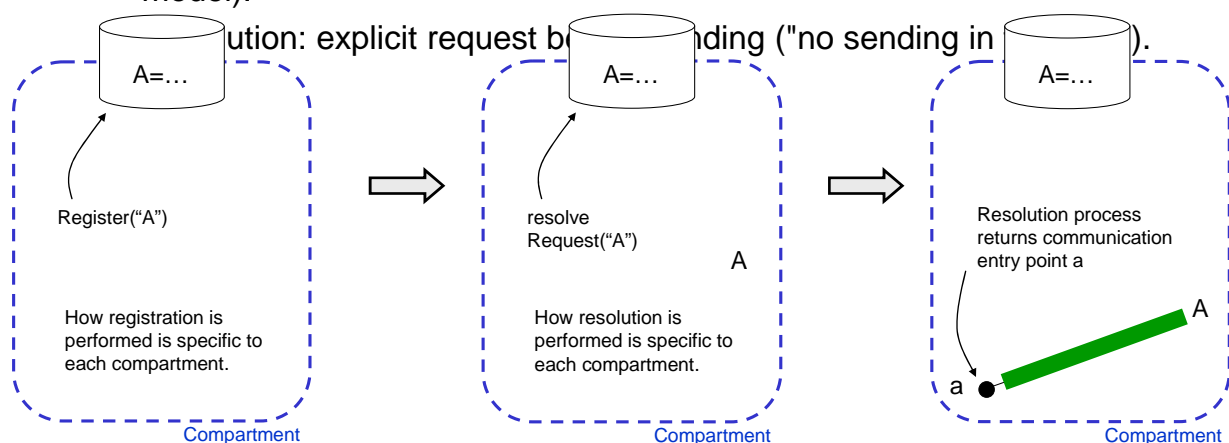
## ANA basic networking unit: the compartment

- A (network) compartment implements the operational rules and administrative policies for a given communication context. It defines:
  - How to join and leave a compartment: **member** registration, trust model, authentication, etc.
  - **How to reach** (communicate with) another member: peer resolution, addressing, routing, etc.
  - The compartment-wide policies: **interaction rules** with "external world", the compartment **boundaries** (administrative or technical), peerings with other compartments, etc.

Compartments decompose communication systems and networks into smaller and easier manageable units.

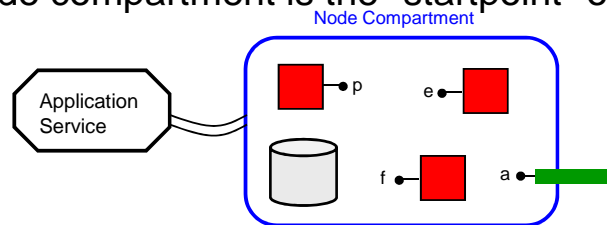
## Compartments (cont.)

- Registration and resolution are key functionalities of compartments.
  - Each compartment defines a conceptual membership database.
  - Registration: explicit joining and exposing is required ("default-off" model).



## Modeling nodes as compartments

- Organize a node's functionalities as (compartment) members:
  - Member database: catalog of available functions.
  - Resolution step to access a given function.
    - Also implements access control.
  - Resolution instantiates functional blocks (FBs).
  - The node compartment hosts/executes FBs and IDPs.
- Applications first attach to the node compartment:  
The node compartment is the "startpoint" of any communication.



## Potential Fields

Potential at node  $n$   
from member  $j$ :

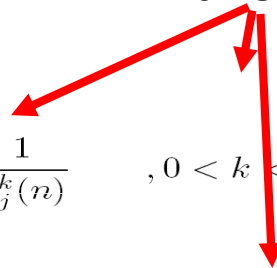
$$\varphi_j(n) = \frac{1}{d_j^k(n)}, \quad 0 < k < \infty$$

Potential at node  $n$   
from group:

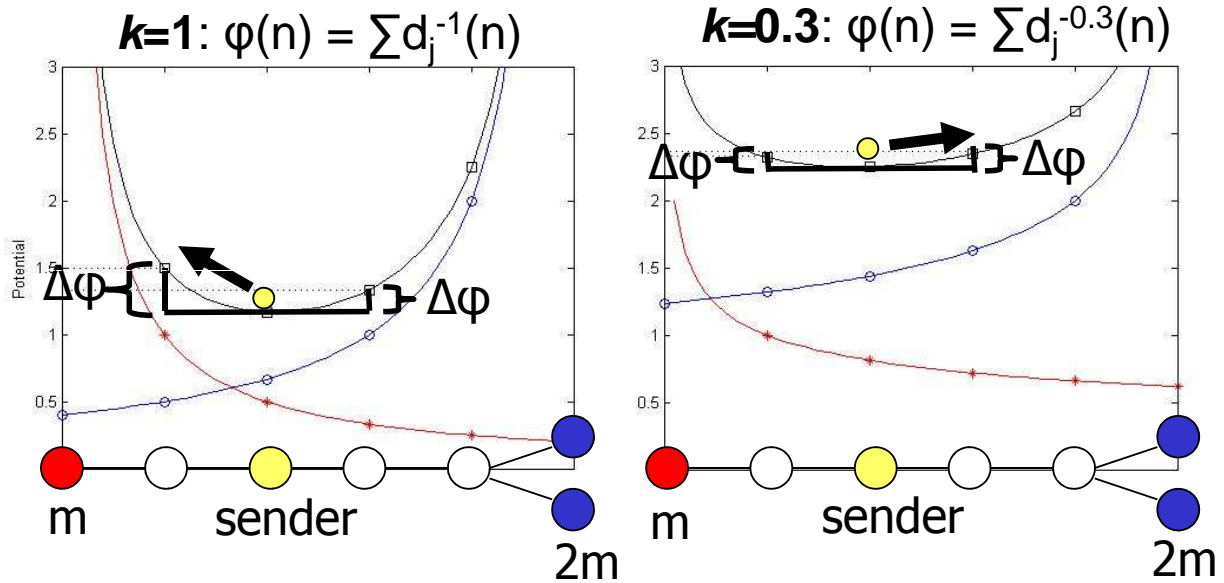
$$\varphi(n) = \sum_{j \in \mathcal{N}} \varphi_j(n) = \sum_{j \in \mathcal{N}} \frac{1}{d_j^k(n)}$$

$d_j(n)$ : distance from node  $n$  to member  $j$   
 $\mathcal{N}$ : anycast group size

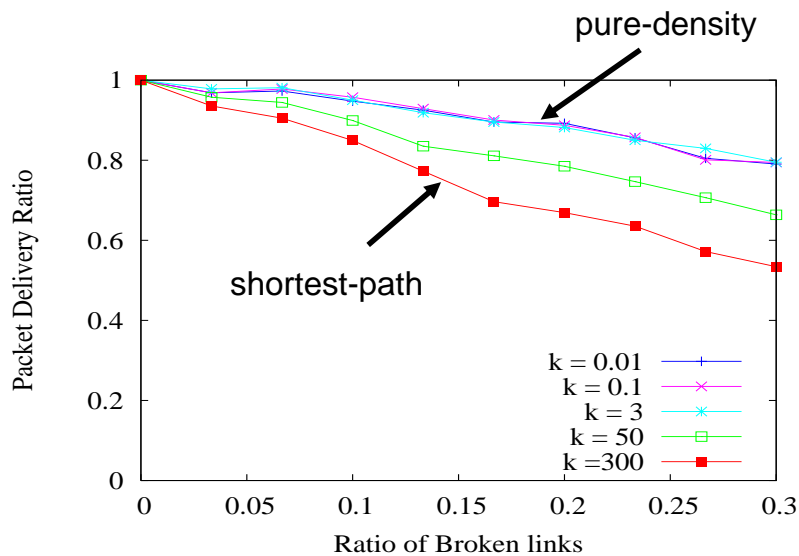
$k$  varies the shape



## Effect of Varying the Exponent $k$ in the Potential



## Density-based routing is more robust



- Simulations with static wireless networks
- Random topologies
- Links fail according to uniform distribution
- 500 nodes
- Group size = 10
- Average over 2000 topologies

# Validation Scenario

