Mobility Support in Information Centric Networking (ICN)

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COST WiNeMo & IEEE/IFIP Wireless Days 2012
Dublin, Ireland, 21 Nov 2012

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- Information Centric Networking (ICN):
  - Motivation
  - Principles
  - Key features and differences
- Mobility support in ICN
  - Receiver mobility
  - Source mobility
- Conclusions

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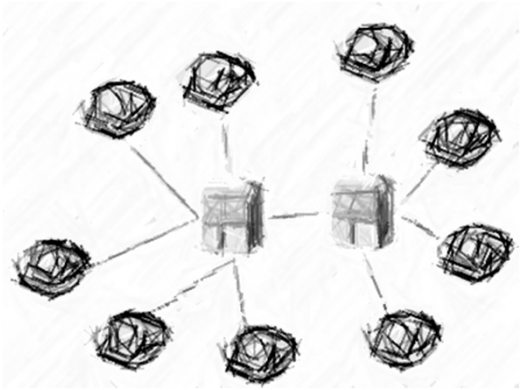
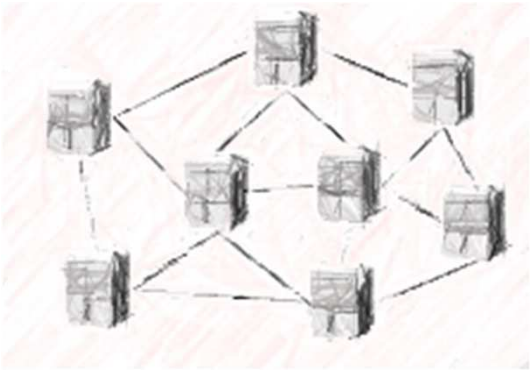
Three network generations

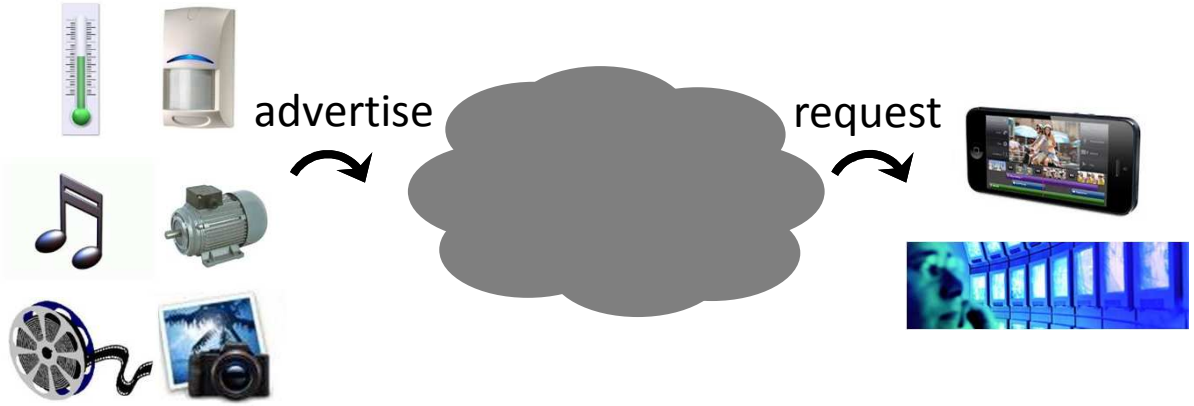
Telephony:
Inter-connected
wires



Internet:
Inter-connect
hosts



ICN:
Inter-connect
information



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Problems with Current Internet

- **End-to-end semantics** is not the prevailing usage paradigm
  - Information-centricity: focus on information itself not where it resides
  - Overlay content delivery structures (CDNs, P2P): ignore network topology and requester/data location
  - Firewalls, NATs, proxy servers
  - ISPs: costly (Deep Packet Inspection-DPI) to find type of information
- **Mobility** support not seamless
  - IP addresses used both as host and location identifiers

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Problems with Current Internet (cont.)

- **Security and trust**
  - Sender controlled transport facilitates DoS attacks
  - Focus on communication security, but information security can be more important
- **Run-time tussles** between various players
  - Imbalance of power – functions not separated when they should be (e.g. well-known port numbers and applications)
  - Ossification of architecture with point solutions/patches
- **Congestion control**
  - End-to-end semantics not appropriate when links have different and variable network conditions
  - flash crowds

Principles of Information-Centric Networking (ICN)

- **Naming of content** rather than hosts/interfaces
  - Departs from host-to-host communication model
  - Content **independent of devices** that store it
  - Names are **location independent**
- **Receivers (subscribers) request content**
  - Receiver control
- **Sources (publishers) advertise content**
  - Need to **match** requests to advertised content
- Receivers and senders
  - do **not have to be aware of each other**, and
  - are **decoupled in time**

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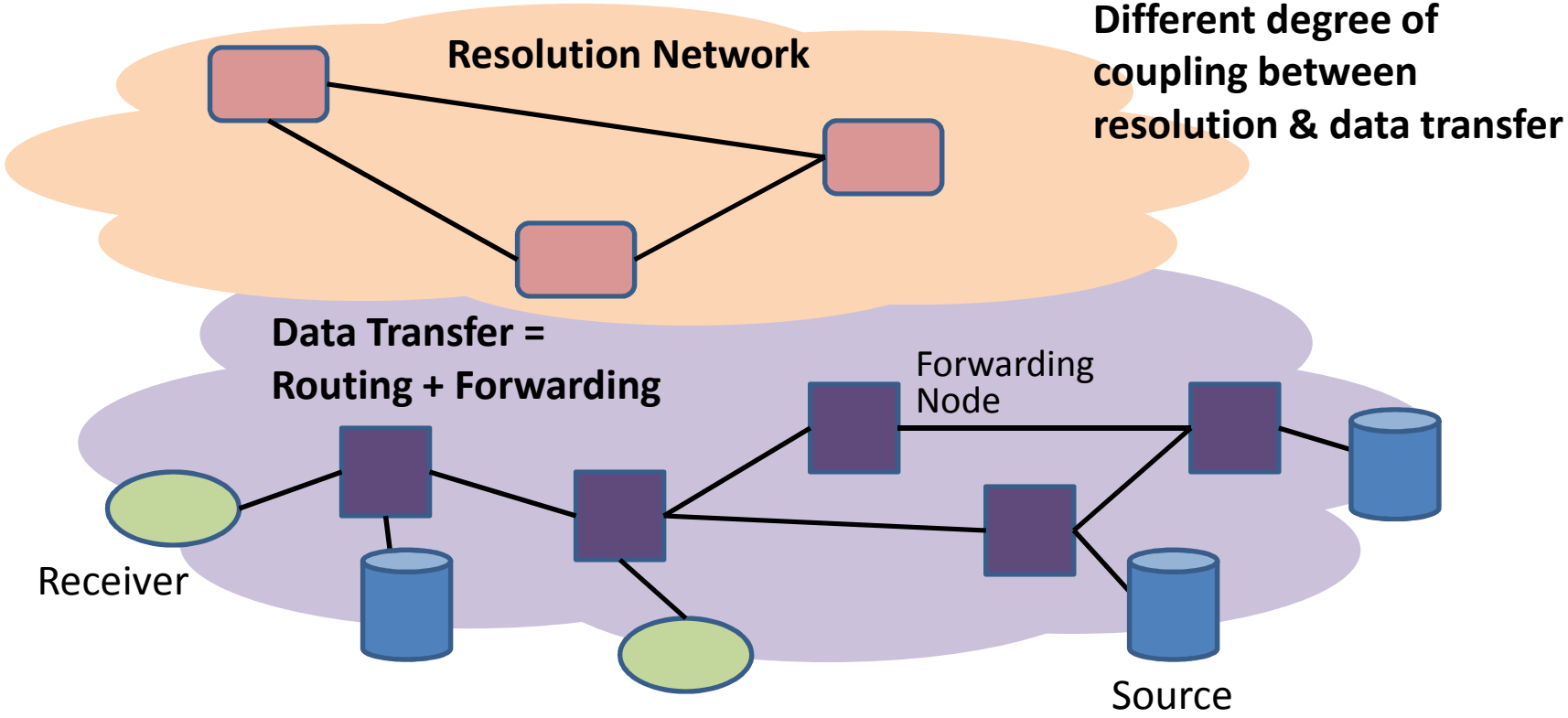
Basic Functions of ICN



- **Name resolution:** Match requests to content advertisements
- **Routing (topology formation):** Determine path from source (publisher) to receiver (subscriber)
- **Forwarding:** Transfer content from source to receiver

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… but isn't previous picture an IP network ?

ICN principles make the difference:

- **Naming of content** rather than hosts/interfaces
  - DNS: location-dependent names
  - IP: location-dependent addresses used as both host & location identifiers
- **Receivers (subscribers) request content**
  - IP: sender has all power
- **Sources (publishers) advertise content and network matches requests to content advertisements**
  - IP: user needs to know or find out where to get content
- **Receivers & senders don't have to be aware of each other**
  - IP: both sides of a connection know other side's location-dependent address

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Key Advantages & Features of ICN

- **Receiver mobility** support
- In-network **caching**
- **Content-aware** traffic management
- **Hop-by-hop** transport & congestion control
- **One-to-many/any** and **many/any-to-one** communication modes

- ICN architecture proposals differ in **degree of coupling** between
  - name resolution & data transfer
  - data routing & forwarding

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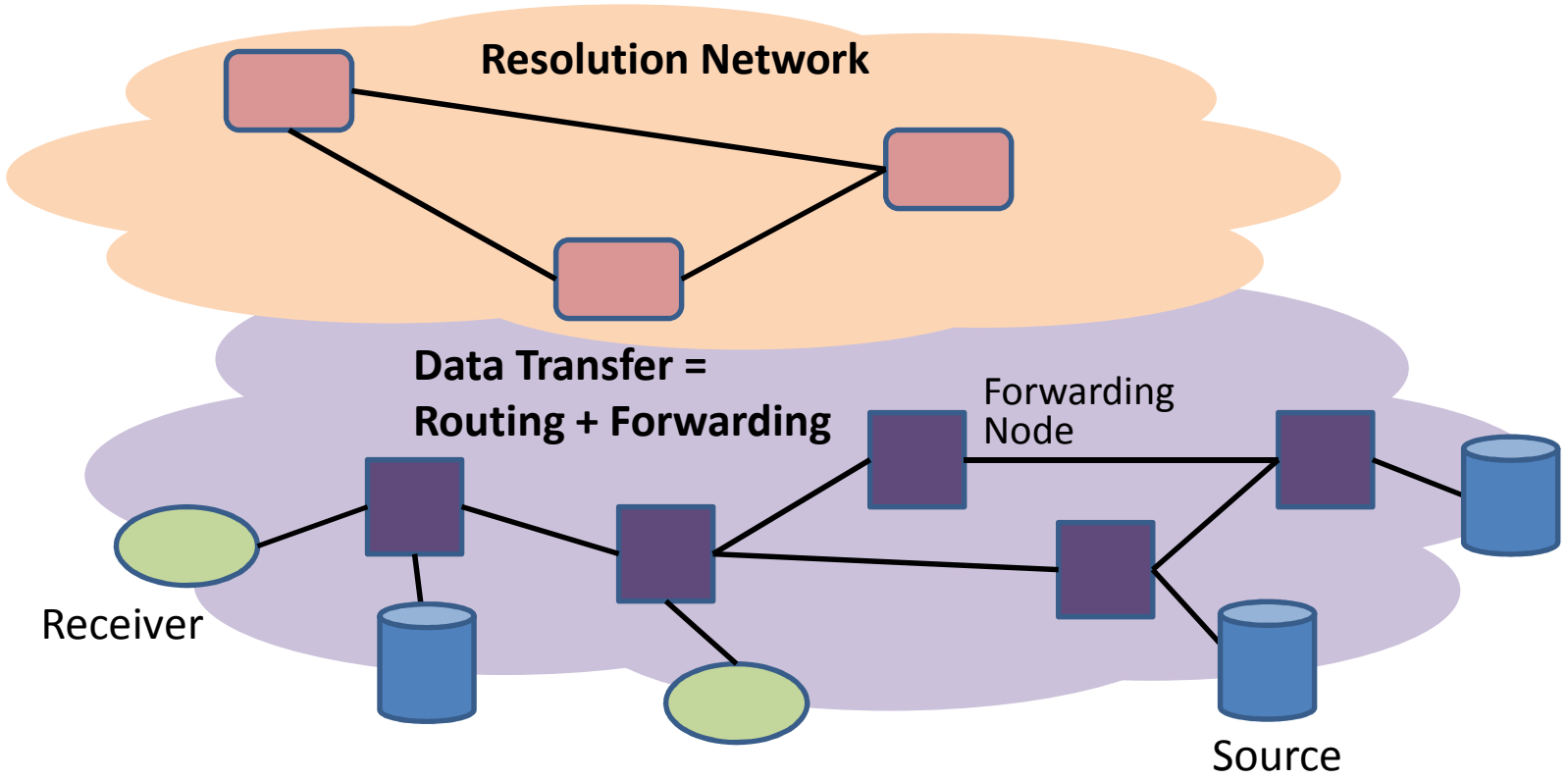
Name Resolution and Data Transfer



Different degree of coupling between resolution & data transfer

- Decoupled: different nodes perform resolution & data transfer (similar to DNS)
- Coupled: nodes perform resolution and data transfer

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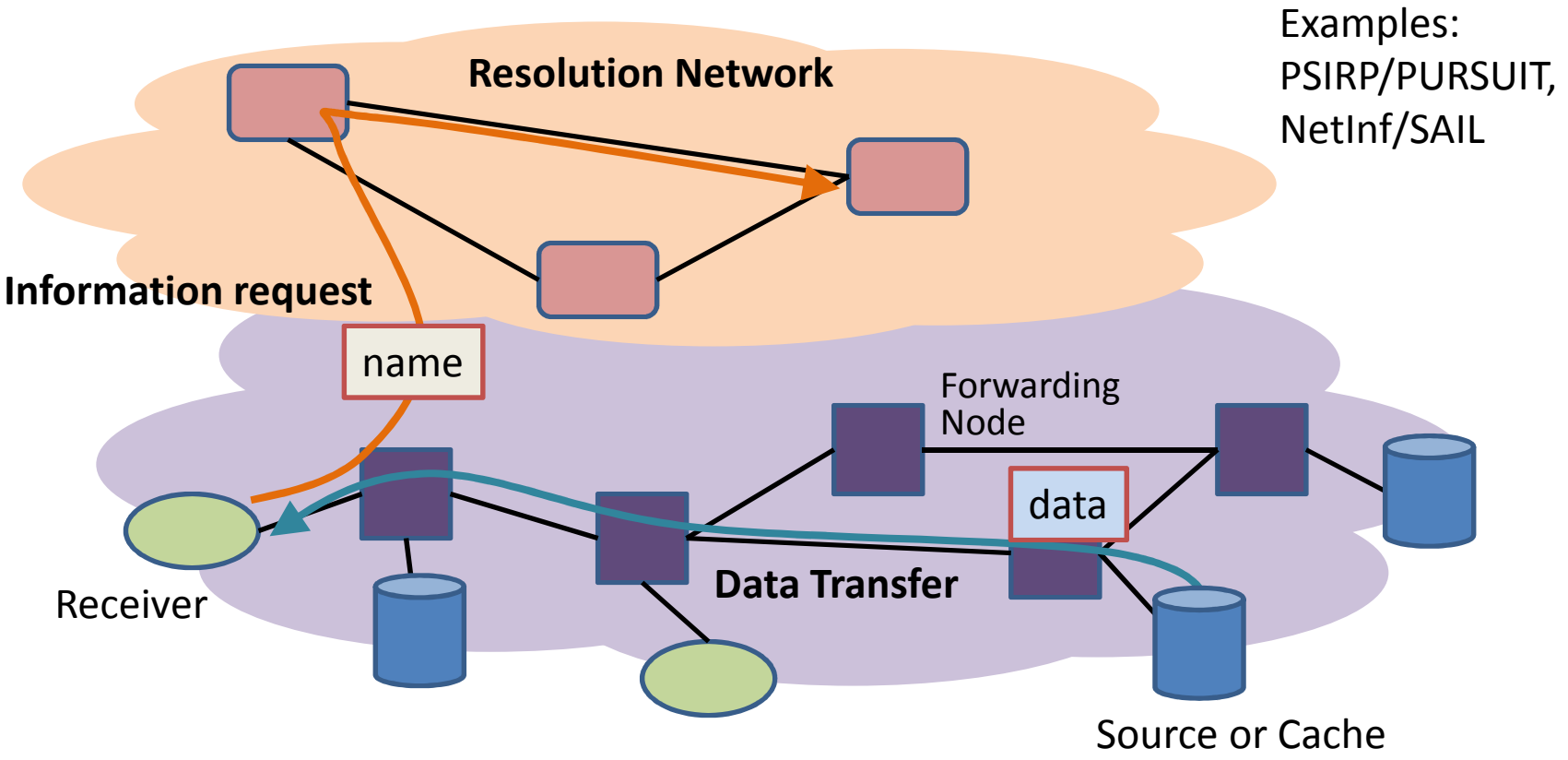
Decoupled Resolution & Data Transfer



- Resolution function matches requests to sources or caches (in-network caches)
- Data path independent of request (control) path

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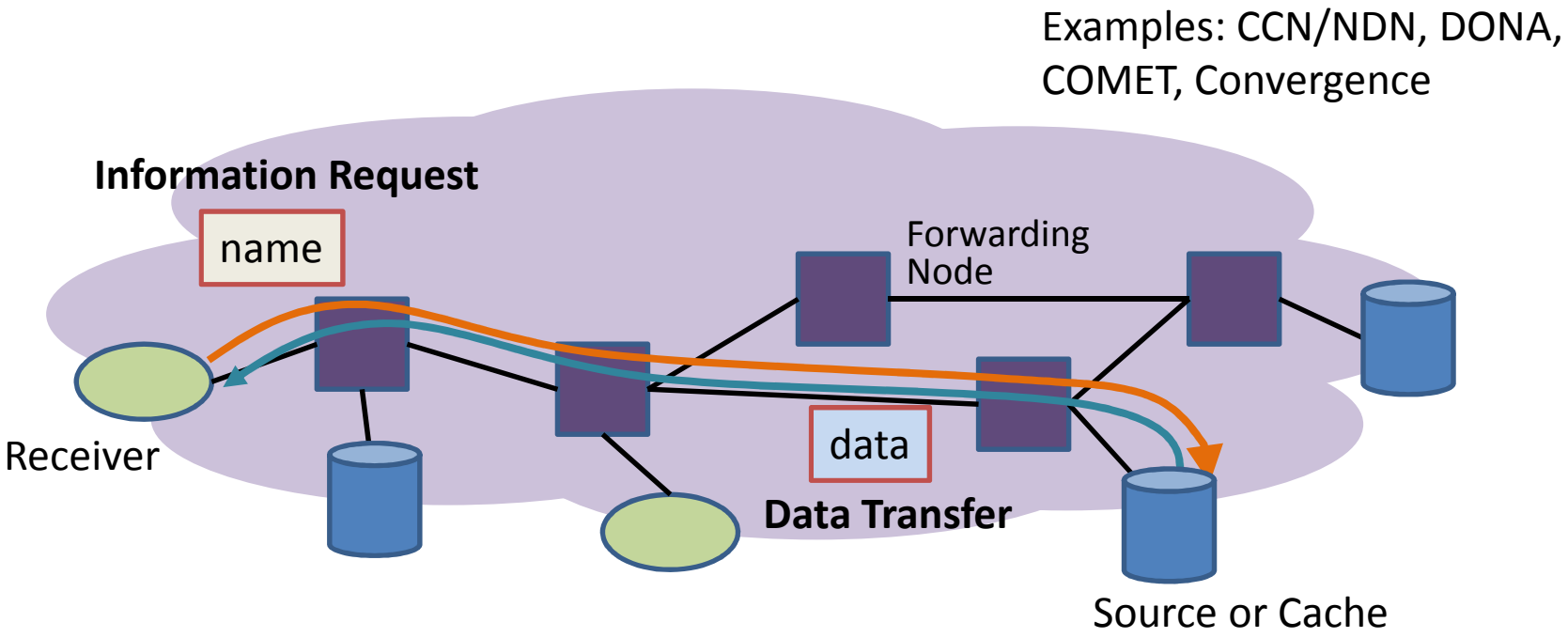
Coupled Resolution & Data Transfer



- Nodes route information requests to source or cache (in-network caching)
- Data path inverse of request (control) path

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Tradeoffs from different coupling of Name Resolution & Data Transfer

- Coupled
  - Data path reverse of request (control) path
  - In-network caching simpler through local mechanisms for routing requests
- Decoupled
  - Support for advanced policies (e.g. QoS, interconnection agreements)
    - Implemented by one function without affecting the other
  - Exploitation of different paths for control & data (e.g. low-delay path for control and high bandwidth path for data)
  - Separation of functions addresses tussles & allows competition
  - More choices for supporting source mobility

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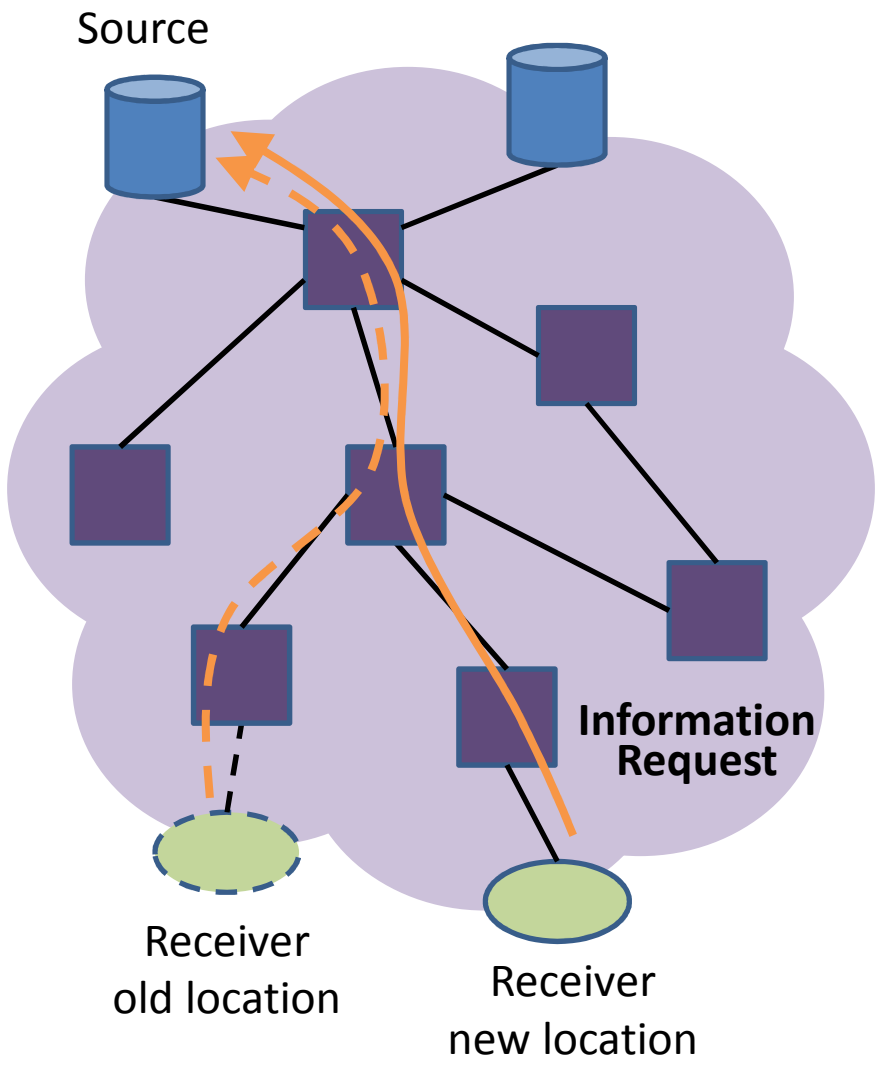
Receiver mobility

Receiver mobility supported by design:

- Receiver-driven content request model
- No end-to-end session establishment such as TCP
- Individual chunks/packets are named hence can be requested individually



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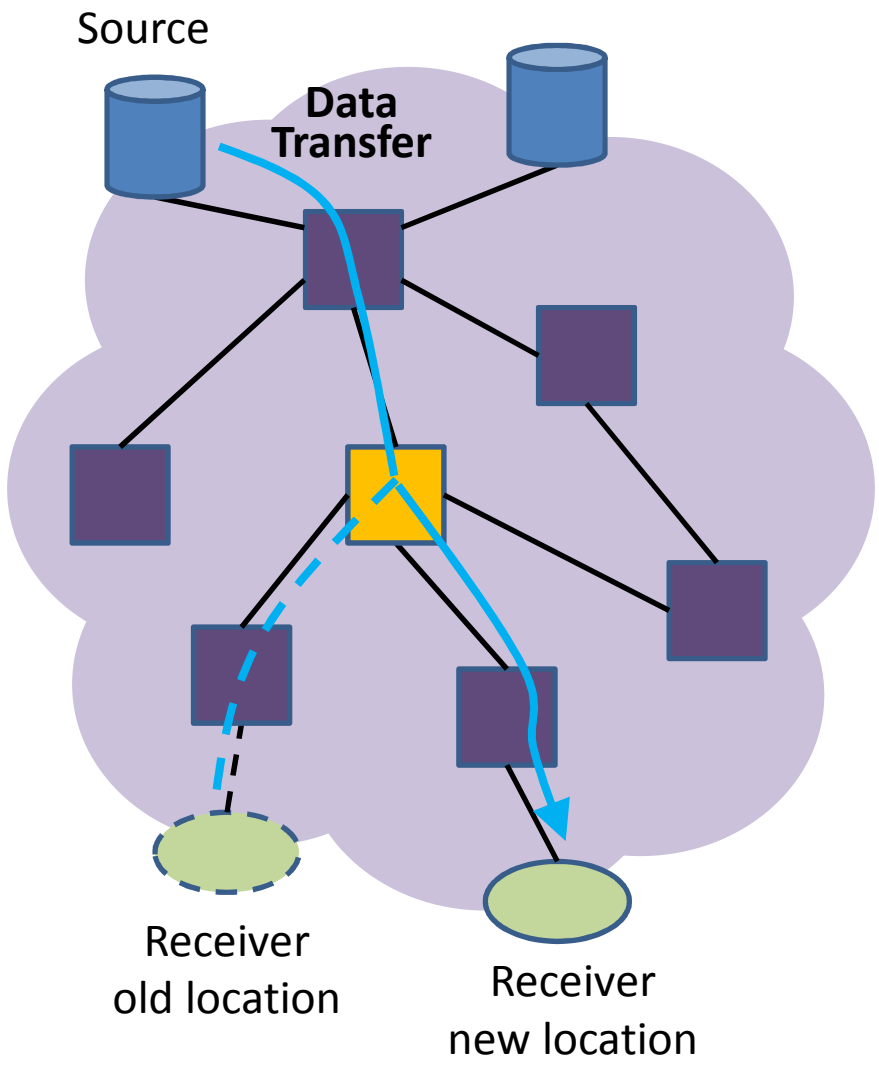
Receiver mobility and caching

- In-network caching can assist receiver mobility
- Caches along path followed by request can provide data
  - Possible with naming of content chunks/packets
- Further optimization: use caches proactively



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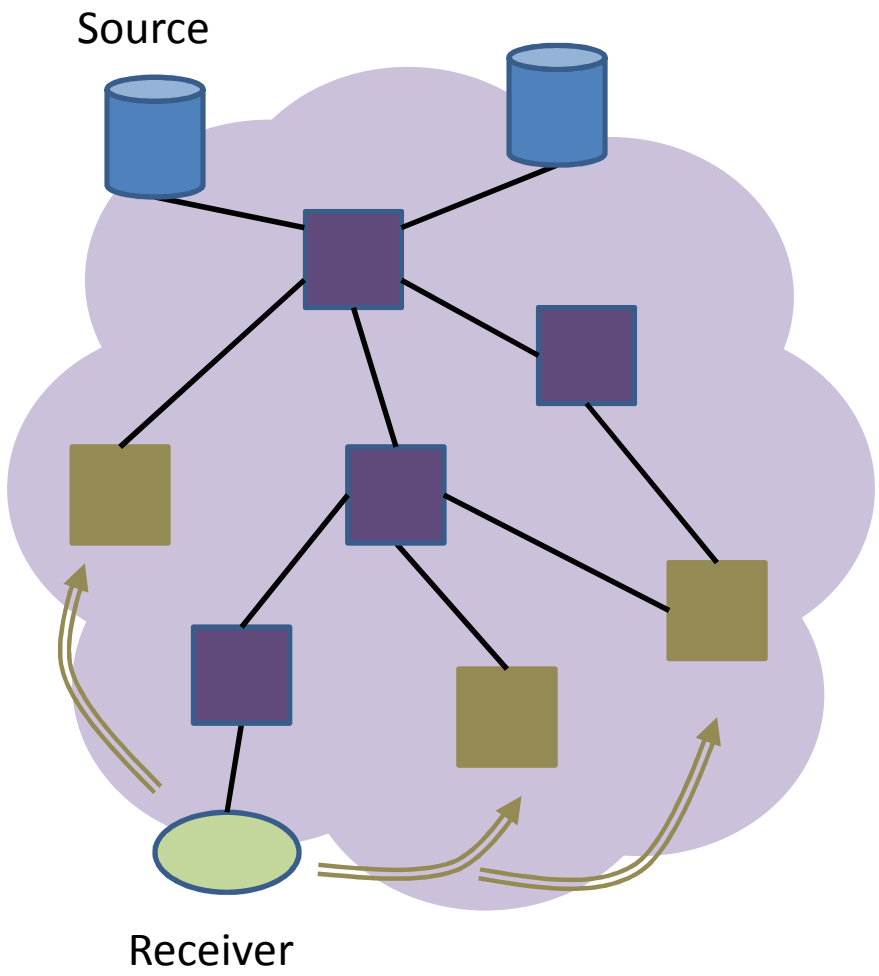
Receiver mobility and proactive caching

- Transfer content requests to one-hop neighbors
  - Prefetch content at neighbors when mobile disconnects
- Wasted resources if we prefetch content to all neighbors



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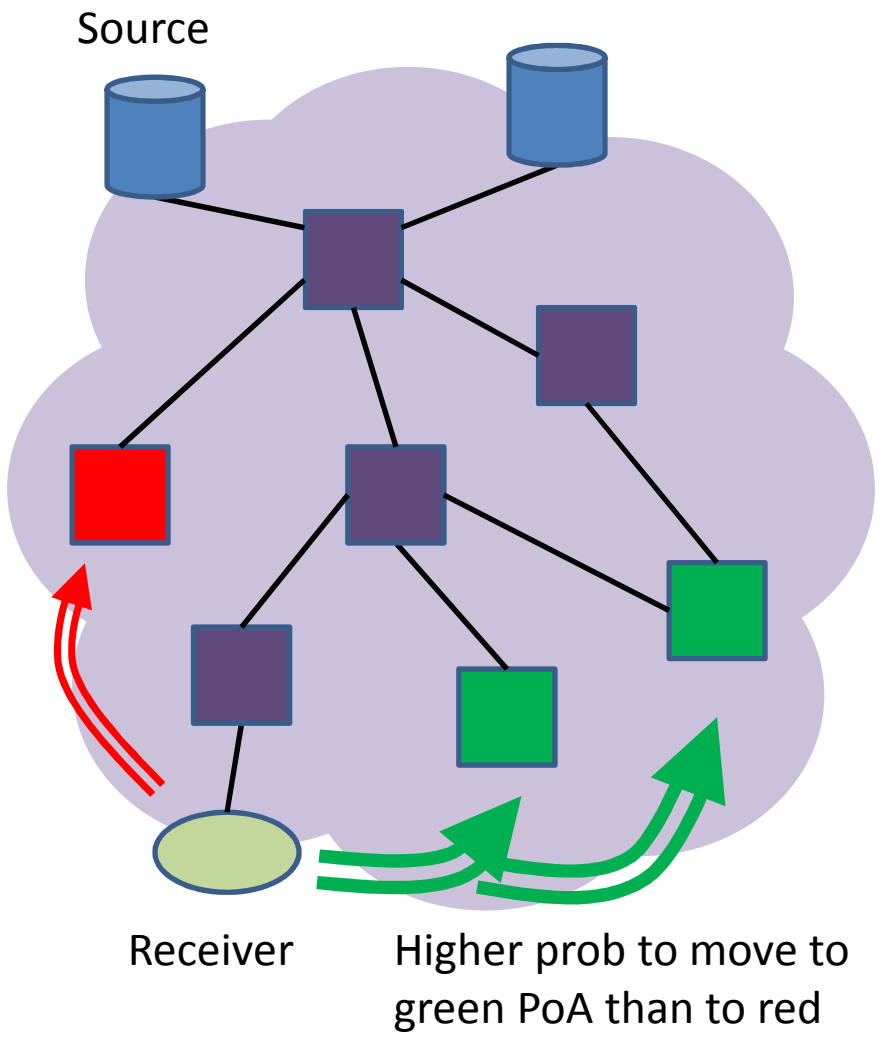
Receiver mobility and proactive caching

- Transfer content requests to one-hop neighbors
  - Prefetch content at neighbors when mobile disconnects
- Wasted resources if we prefetch content to all neighbors
- Select subset of neighbors based on transition probability ⇒ Selective Neighbor Caching (SNC)



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Source mobility

- Not as straightforward as receiver mobility
  - Receiver-driven (pull) model helps receiver mobility
  - Requests need to be “matched” to sources
  - Requests contain location-independent names
- Two problems need to be addressed
  - Find source’s new location: to forward content requests
  - Achieve session continuity: reduce or avoid service disruption and data loss/delay

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Source mobility approaches

- **Routing-based** approach
  - Routing tables updated when source moves
  - Only solution if no location-dependent addresses
- **Indirection** approach
  - Agents at home and visited network
  - Need location-dependent addresses
- **Resolution** approach
  - Requires separate resolution function

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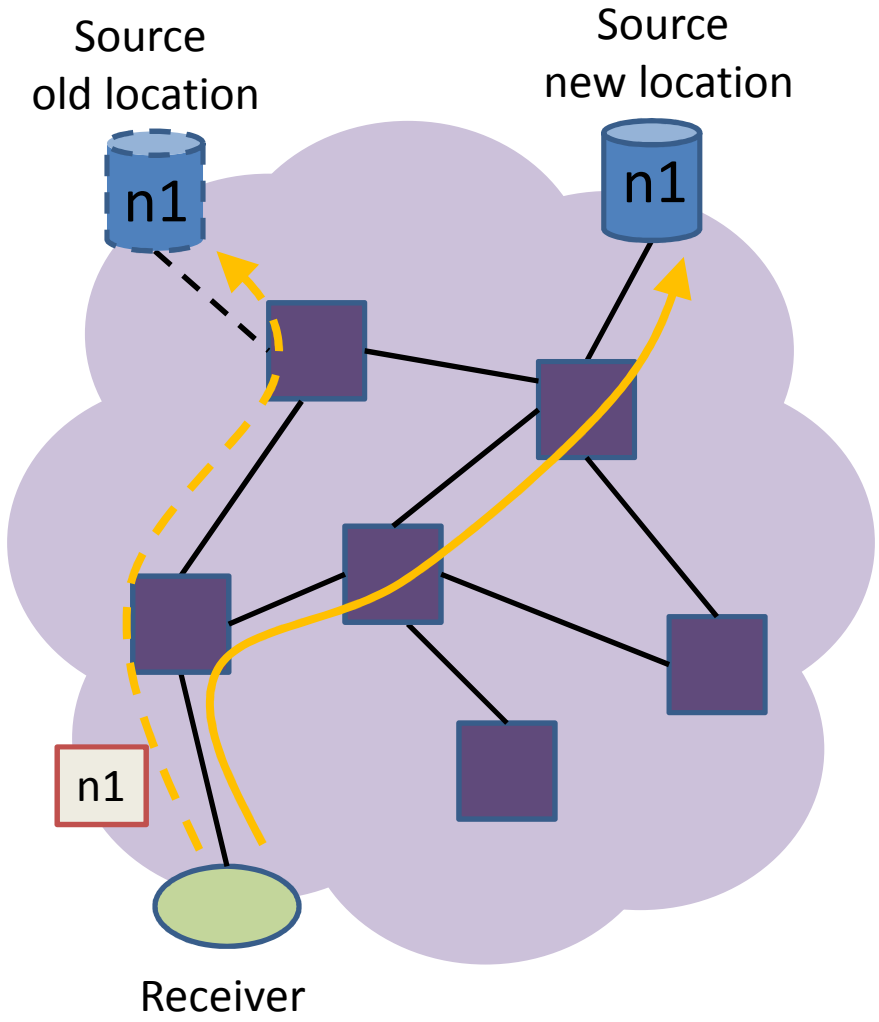
Source mobility: routing-based

- Requests forwarded using routing tables
- Routing tables populated based on content advertisements
- Source mobility would trigger new content advertisements. Issues:
  - Convergence time
  - Routing table scalability
  - Smaller problem in case of micro-mobility
- Optimization: Proactive content advertisements
- How data is forwarded from source to receiver depends on specific architecture



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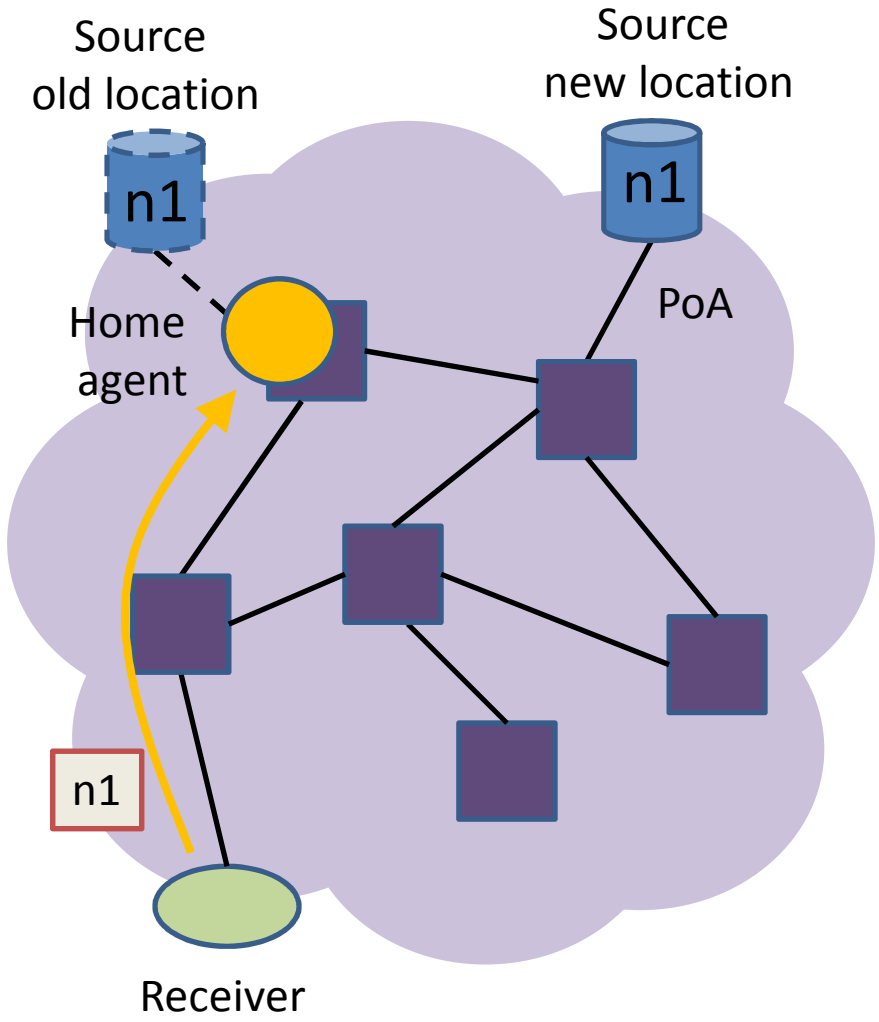
Source mobility: indirection approach

- Home agent forwards requests to new source location
  - Requires location-dependent identifiers
  - Similarities with Mobile IP



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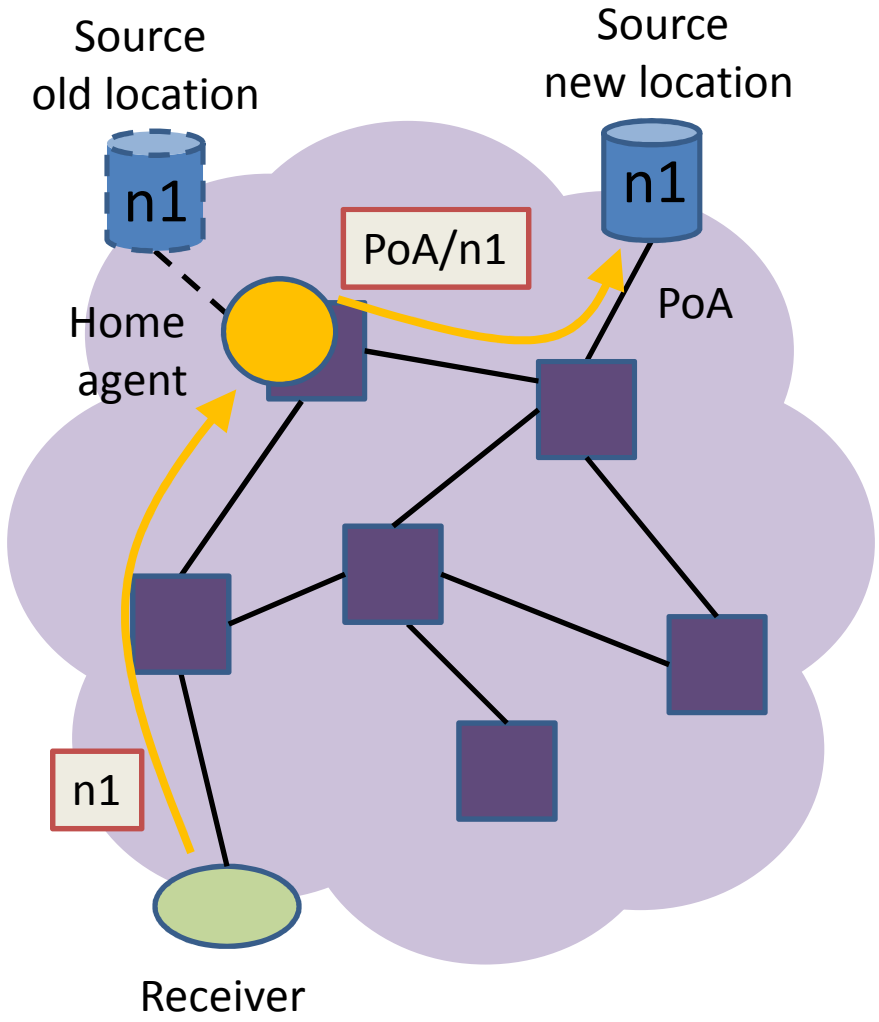
Source mobility: indirection approach

- Home agent forwards requests to new source location
  - Requires location-dependent identifiers
  - Similarities with Mobile IP
- Agents in visited network can help transparency
  - Automatically add location prefixes
- Disadvantages:
  - Communication goes through home agent



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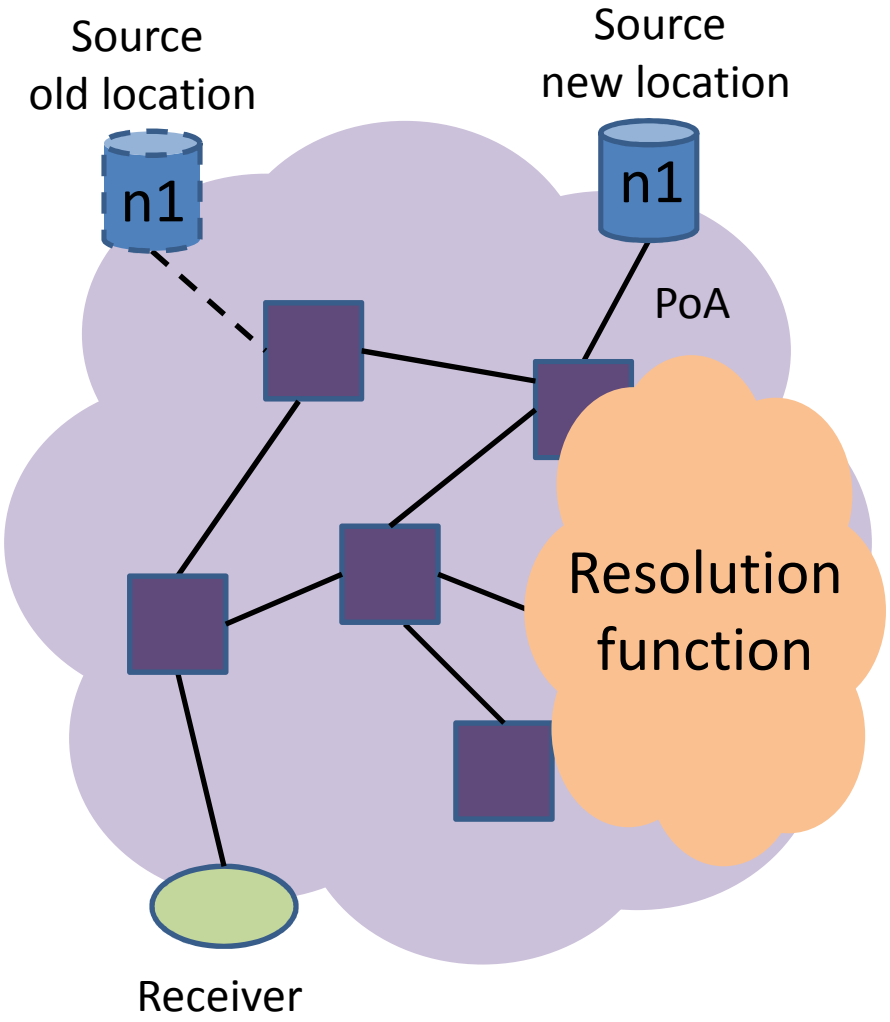
Source mobility: resolution approach

- Resolution function already exists when resolution and data transfer decoupled
- Resolution table updated with current location ⇒ need location-dependent ids
- Separation of identity-locator not new: Host Identity Protocol (HIP), Identifier-Locator Network Protocol (ILNP)



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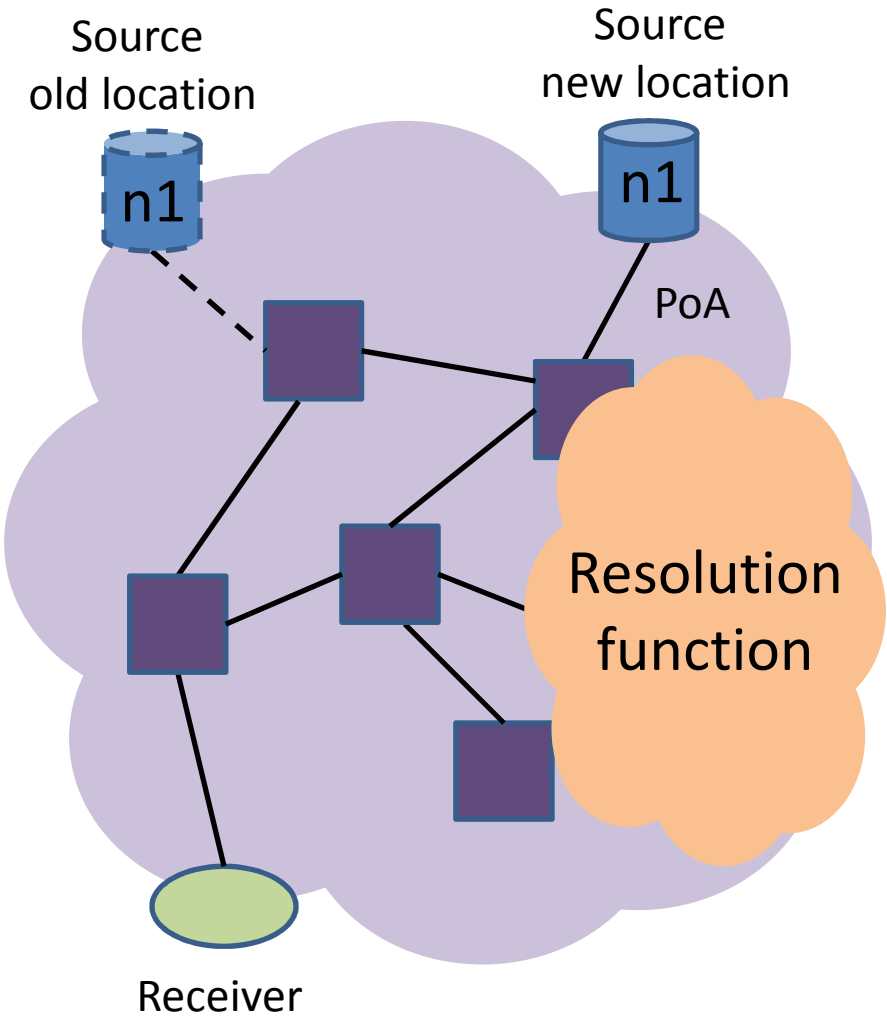
Source mobility: resolution approach (2)

- Resolution function can be provided by
  - Independent resolution network
  - Home agent
- Issue: Resolution overhead, only for first communication
- How data is forwarded from source to receiver depends on specific architecture



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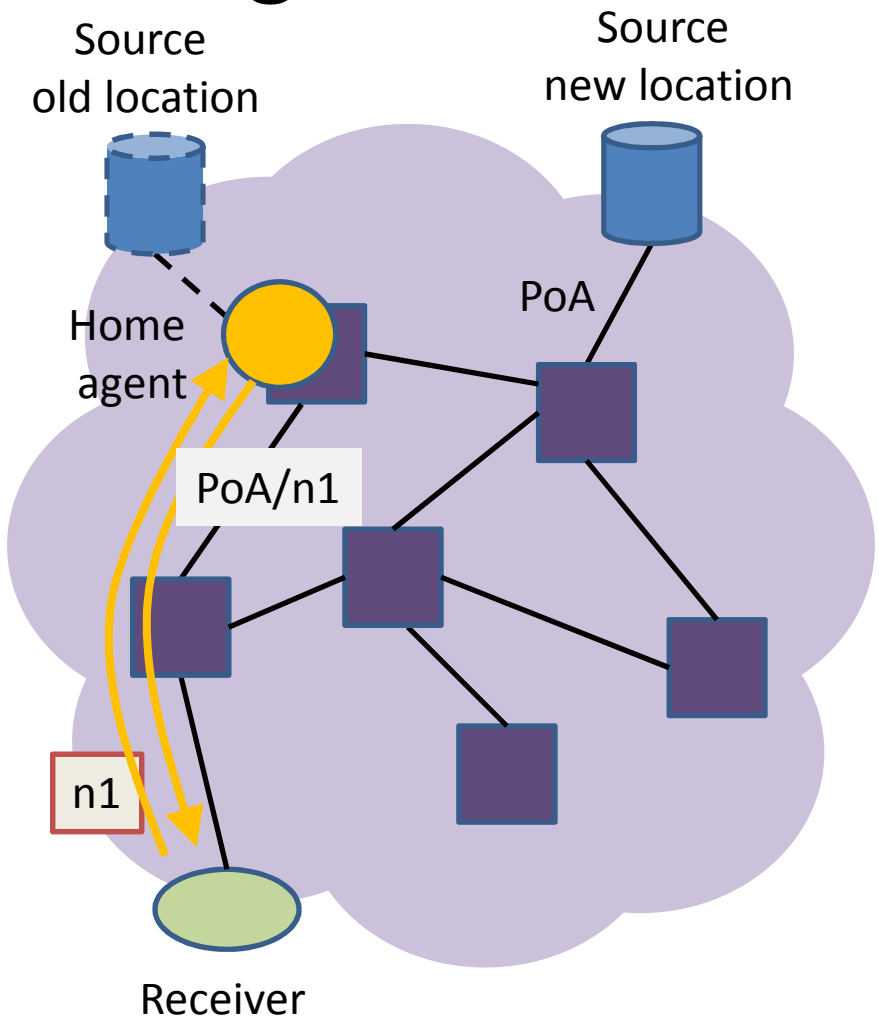
Source mobility: resolution approach based on home agent

- Home agent: binding between name and location
  - Location id: PoA prefix+name
  - Updated when source moves
- Request for content n1 routed to home agent
- Home agent responds with PoA/n1



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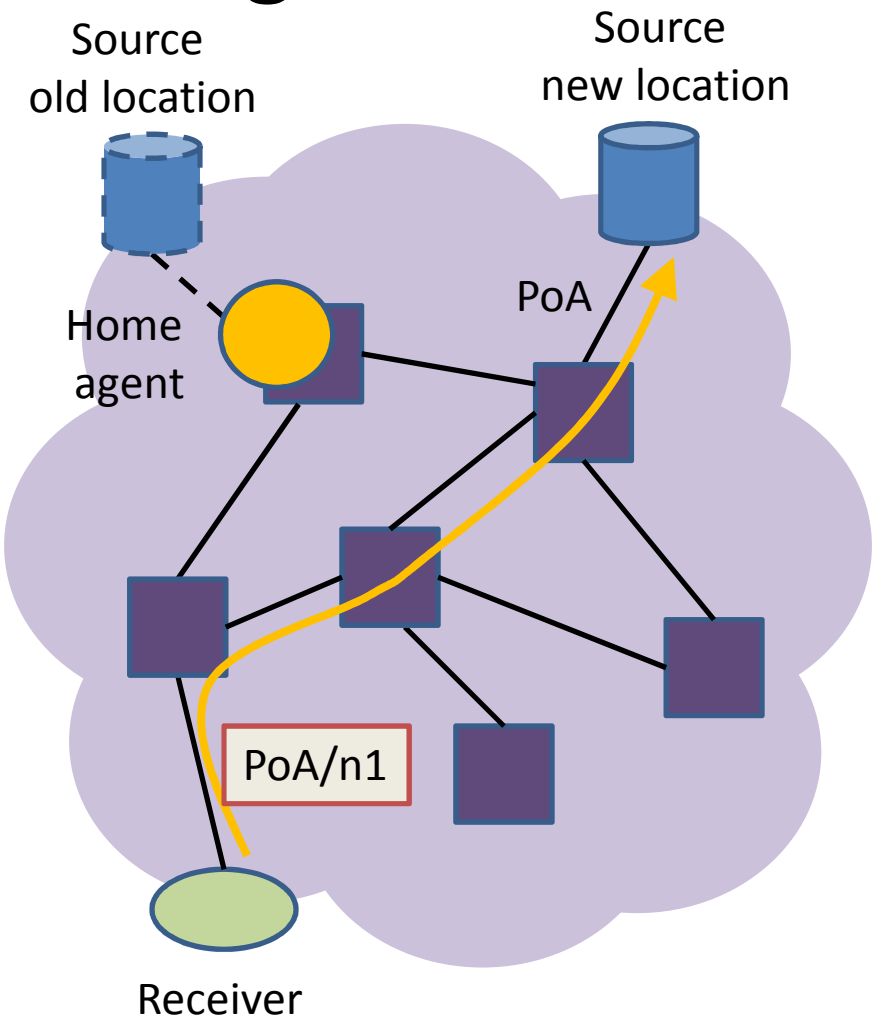
Source mobility: resolution approach based on home agent

- Home agent: binding between name and location
  - Location id: PoA prefix+name
  - Updated when source moves
- Request for content n1 routed to home agent
- Home agent responds with PoA/n1
- Receiver requests PoA/n1



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Source mobility: session continuity

- Mechanisms at mobile nodes help
  - Moving node informs other side that it will move and possibly where it will move
- Home/visited agents can help achieve transparency
  - Automatically add PoA prefix
  - No changes to mobile nodes

Conclusions

- **Receiver mobility** supported by **design** in ICN
  - **Optimizations** are possible by exploiting **caches**
- **Source mobility** is **more difficult** in ICN
  - With location-independent names only routing-based approach is possible
    - Convergence time and routing table scalability issues
  - **Location-dependent identifiers** necessary to support **efficient source mobility** in the general case
- Both **location-independent names** and **location-dependent addresses** have a **role in future networks**
- **Flexible/dynamic mapping** and **usage** of **names** and **addresses** to find & transfer information is key

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Acknowledgements

- Projects @ AUEB's Mobile Multimedia Lab - http://www.mm.aueb.gr/
  - FP7 ICT PURSUIT (Publish-Subscribe Internet Technology) - http://www.fp7-pursuit.eu
  - ESA (European Space Agency) ϕSAT (The role of satellite in Future Internet architectures)
- COST WiNeMo supported visit to Univ. of Bern (Prof. Torsten Braun)

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Thank You

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