# Potential Based Routing (PBR) for ICN

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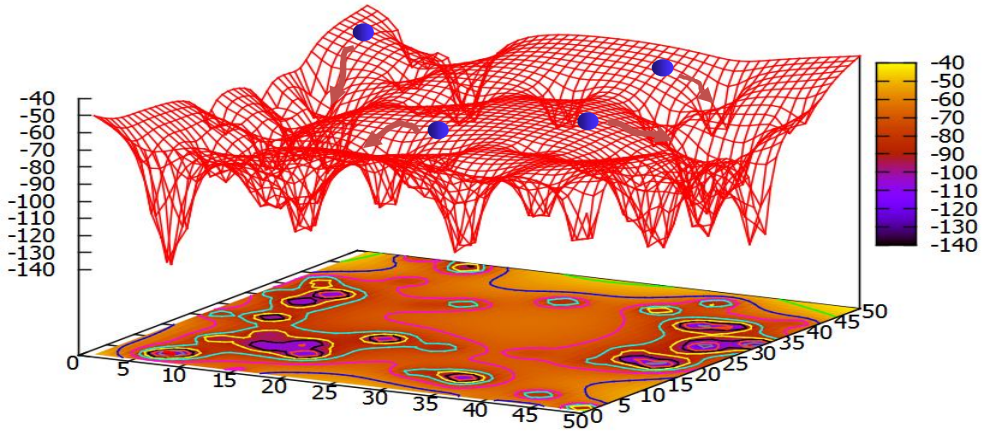
# So which problems are we tackling?

- ICN can be considered as a fully distributed caching architecture.
  - ✓ All ICN elements are aware of users' requests due to the name based routing principle, which means they can respond to the request as well -> an independent content provider.
- We have developed an ICN architecture named CATT to answer following two questions;
  - ✓ How to distribute contents / how to locate them?
- This talk is about the second question "how to locate them" based on "Potential Based Routing (PBR)" .

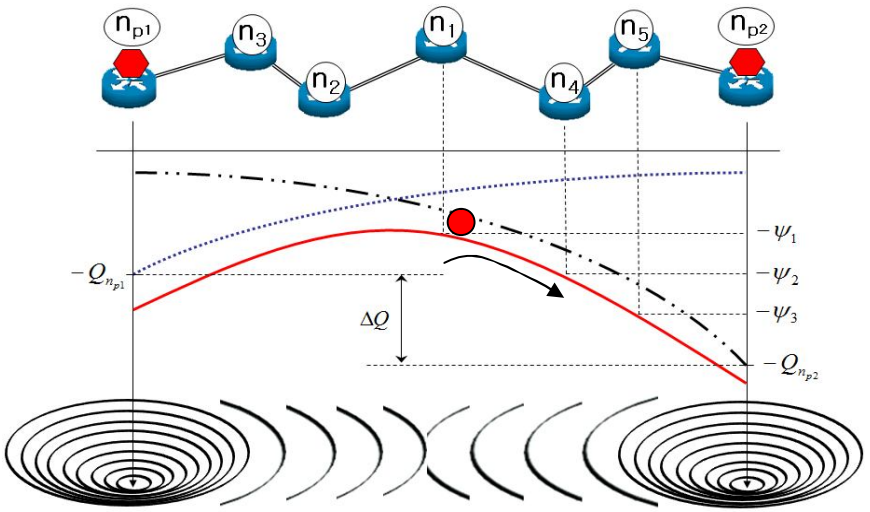
# PBR: its idea

- The idea of PBR is to create a potential field which routes an interest message to a desired content.




**Potential field**: Imagine that there are valleys. When we drop a ball, the ball keeps moving down to a bottom of the field. Similarly, any users' request launched within the field is naturally led to a bottom of the field that represents the location of the requested content.

# PBR: how to create a potential field?




- Blue dot line
  =>Potential field from $n_{p1}$
- Black dot–dashed line
  =>Potential field from $n_{p2}$
- Red solid line
  =>Potential field that are linearly summed from both potential values.

$$\psi(n) = \sum_{j=1}^{N} \frac{-Q_j}{dist(n, n_j)^{\delta}}$$

**Ψ(n):** potential value at node "n".
**N**: the number of nodes which have the content j.
**Q**: Expected quality of the content.
**dist**: distance between node "n" and "$n_j$" with content j.
δ: attenuation factor.

- Red marks at the end of the topology represent nodes with a content file (same files, N=2).
- Node with a content file floods an adv-message which has the fields of Q (quality indicator), and "dist". "dist" is set to one initially, and its value increases by one every time it moves forward.
- The other nodes which receive the adv-message calculate its own potential value using the equation above.
- In the above example, the red solid line represents the potential field created by two end nodes. Thus, when an interest messages (red-ball) is launched on one of the nodes, it is forwarded to one of the two nodes which have the content.

# PBR: its benefits

- Availability:
  - ✓ A mechanism to incorporate not only an original content file in repository but also copies in caches into the retrieval process of a requested content file since copies are broadly distributed among in-network caches in ICN.
  - ✓ See the backup slides 9 and 10 for its use cases.
- Adaptability:
  - ✓ A variety of routing metric can be easily incorporated into CATT by manipulating potential values.
  - ✓ See the backup slide 9.
  - ✓ We are developing an application (AP: access point design) using CATT.
- Diversity:
  - ✓ Provide abundant routing decision process for users, e.g., based on not only proximity but also several conditions including the capability of provider or its surrounding network condition, etc.
- Robustness.
  - ✓ A centralized system is exposed to a single point failure. how to design a method which is free from such a single point failure scenario?

## How this work related to ICNRG short term goals?

- In this contribution, we aimed to introduce the potential based routing and its use cases. PBR can be documented as an IETF draft,
  - E.g., an ICN routing scheme which improves availability - how can ICN benefit from the highly distributed caching contents (copies) in the network? - especially without deteriorating scalability issue (backup slide 10).
- Discussion points,
  - Hard state vs Soft state.
    - ✓ Wired vs Wireless environment
  - Distance vector vs Link state.
    - ✓ Maintaining a topology map at every node?

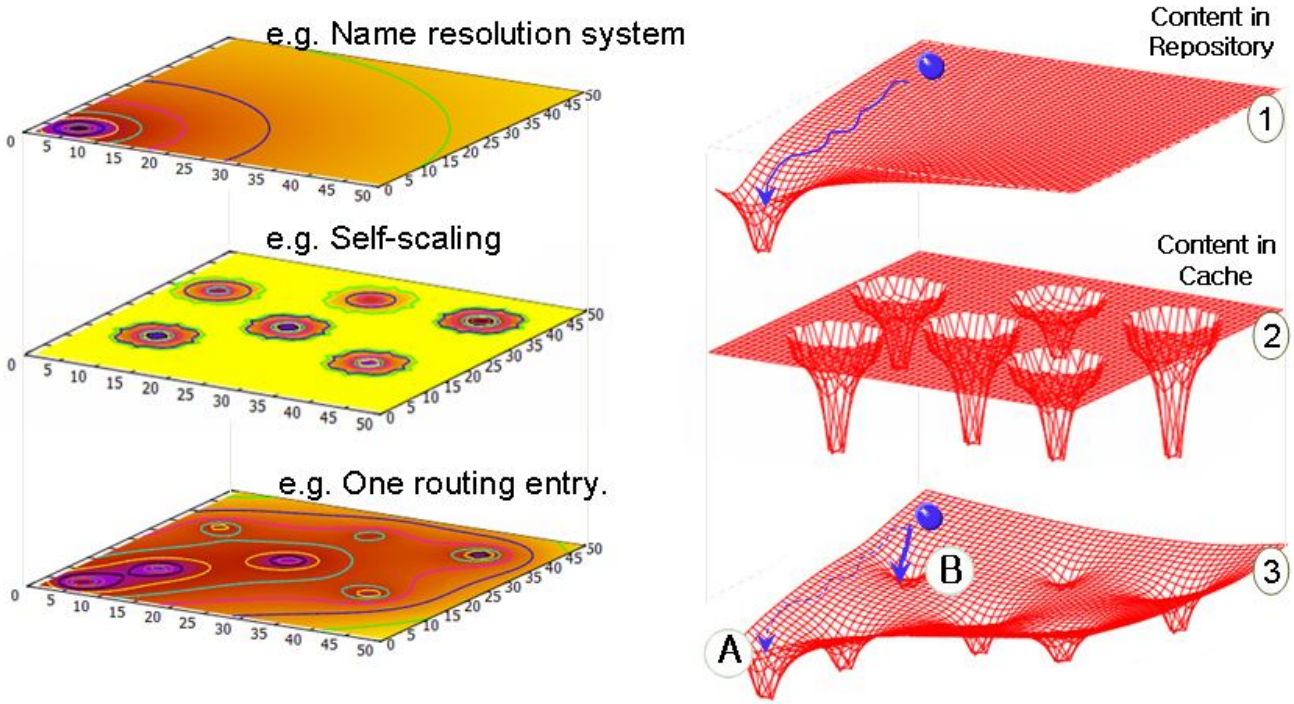
# Backup slides

# Some numbers for ICN design

| | Numbers | Comments & reference |
|---|---|---|
| Size of BGP RT | **$4.5*10^5$** | How many routes can an up-to-date BGP router handle at maximum? + α [bgp.potaroo.net] |
| DONA | **$10^7$** | Back in 2007, that number of data objects could be supported. |
| Domains | **$4.6*10^7$** | Routing with domain names? [www.domainworldwide.com] |
| Indexed web pages | **$5*10^{10}$** | Google's indexed web pages [www.worldwidewebsize.com/] |
| Indexed URLs | **$10^{12}$** | Google's indexed URLs back in 2008 [www.pcworld.com] |
| Copies at caches? | **Scaling by 10 or 100 x (?)** | How many copies are expected per content in ICN? |

- In ICN design, how to achieve availability that takes advantage of highly distributed caching contents without deteriorating scalability issue further - slide 10?

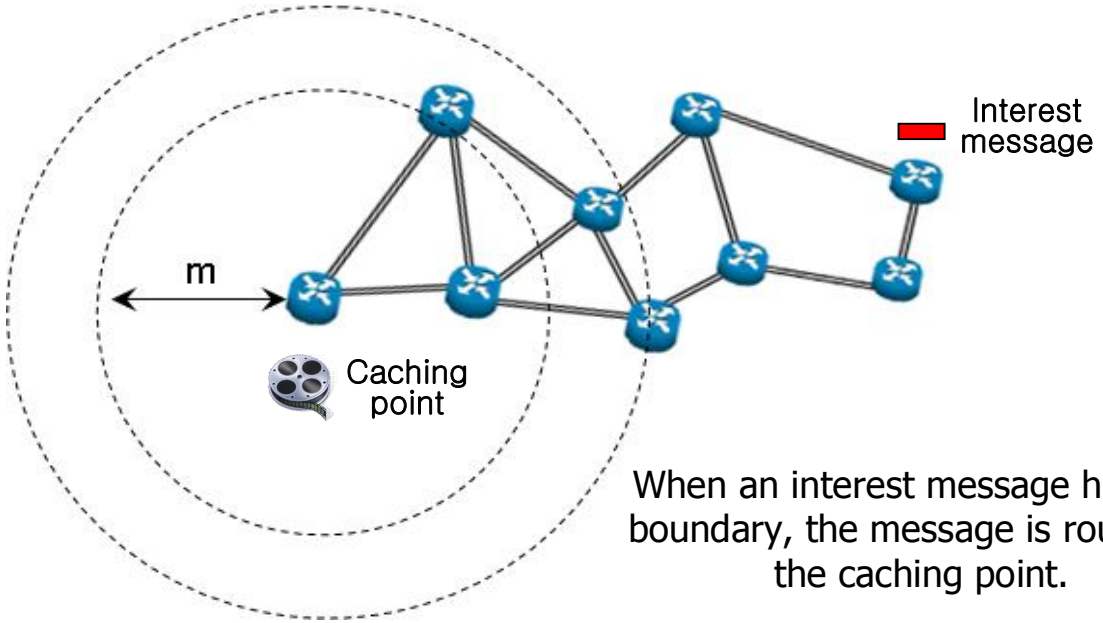
# PBR: A use case 1.




- Top: a potential field is fully defined within an area (intra or inter domain) for an original content.
- Middle: a potential field is defined within a limited scope (one or two hops from caching points).
- Bottom: a potential field which is linearly combined above two fields.
- Thus, while the ball representing a user request moves down to ``A" which represents the location of the originally published content file, it is attracted to ``B" which shows the location of the copied one in the cache.

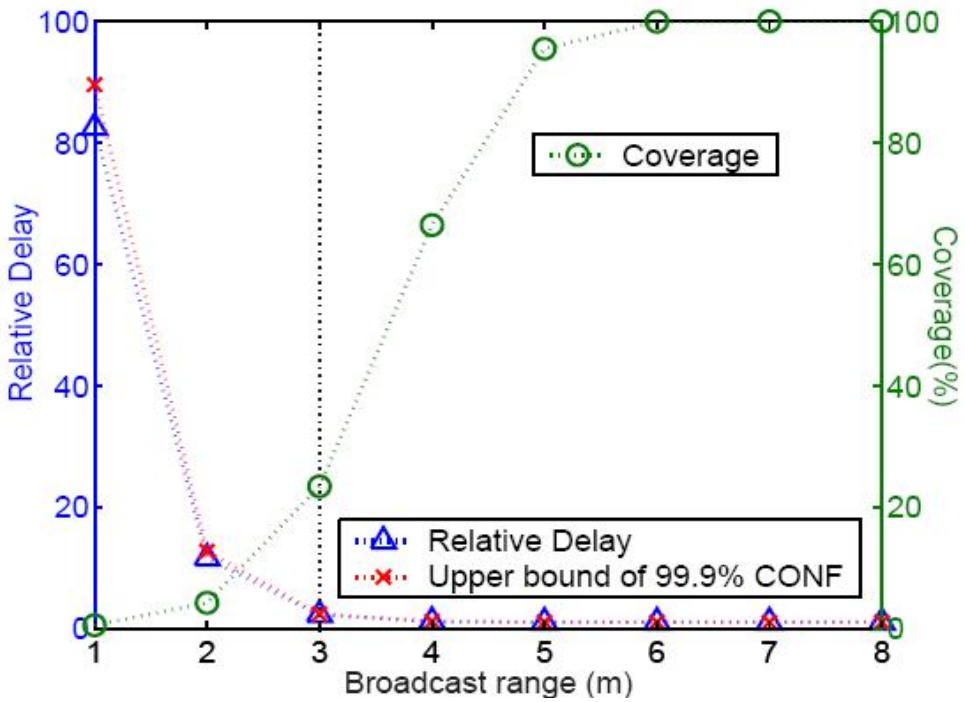
# PBR: A use case 2.

- We may use only the potential field as shown in the middle at slide 9,
- Then, it becomes similar to the breadcrumb routing, "best effort routing" – assumption that a user request is always forwarded to an original provider.
- Let's each ICN element be responsible for advertising or de-advertising its own caching contents within area as much as they can afford – self scaling, selective ads, and active ads (i.e., breadcrumb: passive ads).




When an interest message hits this boundary, the message is routed to the caching point.

# Evaluation result.




- A power law topology (N=1000, E=2000)
- A content file is located on a randomly chosen node.
  - The node floods an ads-message within a limited area (m: hops).
- An interest message is forwarded randomly before it hits the boundary of the limited area.

- Y-axis-left: relative delay compared to the shortest path routing.
  - E.g., 80: 80 times longer than the shortest path.
- Y-axis-right: the percentage of total nodes within the limited area.
- m: refer to the slide 10.

# Current progress

- Developed a prototype ICN software named CATT which
  - Distributes contents in the network based on several on-path caching algorithms.
  - Locates a content file based on the potential based routing.
- Its performance evaluation based on simulation study will be presented in SIGCOMM ICN workshop 2012.
- One issue currently we are tackling is how to verify the content staleness at cache.