Caching in Named Data Networking for the Wireless Internet of Things

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Introduction

- The Internet of Things (IoT) gains more and more importance. This introduces a change in data being transmitted from big, static files to small, transient data like sensor readings.
- Wide variety of devices: Small sensor nodes, smart phones or even vehicles. Many devices have limited resources in terms of battery capacits or memory size. Often these devices are using a wireless connection to a network [1].
- This research introduces a new caching strategy, namely ***pCASTING (probabilistic CAching STrategy for the Internet of thiNGs)***.

Named Data Networking

- Named Data Networking (NDN) is a content dissemination architecture for the future internet. It employs hierarchical URI-like content names. To access data, only the data name is needed, as opposed to the current internet, where the specific host providing the data needs to be known.
- Data requests are transmitted as ***Interest Packets*** and responses in ***Data Packets***. Interest Packets are forwarded by nodes until a node can respond with the requested data, which is then transmitted back along the forwarding path.

Caching in NDN

- Nodes can ***cache*** data and respond with the cached value instead of forwarding an Interest Packet to other nodes. This can decrease retrieval times for requesting nodes.
- Probabilistic caching strategies cache data at a given probability like $p = 0.5$, with CE^2 (Cache Everything Everywhere) being a special case of $p = 1$[2].

The pCASTING caching strategy

- The caching strategy targets ***simplicity*** and ***no overhead***. It is independent from the underlying routing protocol[3].
- pCASTING calculates a probability at which a data packet is cached in a node. The node then decides to cache a package with the calculated probability.
- The following attributes of a node are taken into account:
  1. The node's energy level $0 \leq EN \leq 1$
  2. The node's current cache occupancy $0 \leq OC \leq 1$
  3. The residual freshness of the data $FR = 1 - \frac{currentTime - t_s}{f}$ with t_s being the timestamp at which the data was sampled and f indicating for how long a datum is valid.
- The caching probability F_u is defined as the weighted sum of the above attributes:

$$F_u = w_1 \cdot EN^n + w_2 \cdot (1 - OC)^n + w_3 \cdot FR^n \quad (1)$$

with $0 \leq w_i \leq 1, n \geq 1$ and $\sum_{w_i} = 1$.

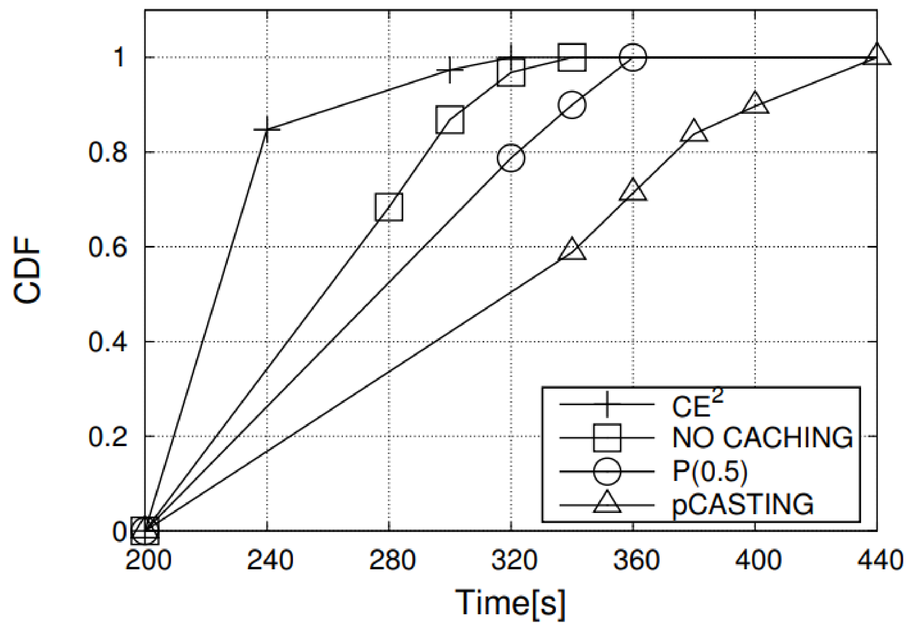
Quellen

[1] M. A. Hail, M. Amadeo, A. Molinaro u. a., "Caching in Named Data Networking for the wireless Internet of Things," in ***2015 International Conference on Recent Advances in Internet of Things (RIoT)***, IEEE, Apr. 2015.

[2] S. Tarnoi, K. Suksomboon, W. Kumwilaisak u. a., "Performance of probabilistic caching and cache replacement policies for Content-Centric Networks," in ***39th Annual IEEE Conference on Local Computer Networks***, IEEE, Sep. 2014.

[3] M. Amadeo, C. Campolo, A. Iera u. a., "Named data networking for IoT: An architectural perspective," in ***2014 European Conference on Networks and Communications (EuCNC)***, IEEE, Juni 2014.

Figure 1



Cumulative Distribution Function of the discharge time of the nodes in the network.

Table 1

Metric	CE^2	No Caching	P(0.5)	pCASTING
Cache hit ratio	42%	0	49%	61%
Consumers' received data pkts	206	208	217	239
Data retrieval delay[s]	0.2	0.34	0.18	0.12

Data dissemination performance metrics for the different caching strategies.

Evaluation

- Performance of pCASTING was evaluated by simulating 70 mobile nodes as well as fixed Access Point and sensor nodes
- Simulations were compared with ***Cache Everything Everywhere***, ***No Caching***, and $P(0.5)$ caching strategies

Network Lifetime Analysis

- pCASTING has a beneficial effect on the energy consumption of nodes, i.e. they were operational for longer
- Using pCASTING, less radio transmissions in the overall network are needed

Retrieval Performance Analysis

pCASTING performs better in terms of cache hit ratio and data retrieval delays compared to the other evaluated caching strategies.

- Data is delivered faster to consumers
- Less radio transmissions are neede for data retrieval

Conclusion

- pCASTING proves to be useful in mobile applications of Named Data Networking.
- It can be extended to take more parameters and attributes into account and may thus be subject to further research on the topic of caching in Named Data Networks.