Caching in Named Data Networking

UNIVERSITÄT ZU LÜBECK
INSTITUT FÜR TELEMATIK

Christoph Langhans - Universität zu Lübeck - Institut für Telematik - Email: christoph.langhans@student.uni-luebeck.de

I. Named Data Networking

NDN is a content dissemination architecture with hierarchical URI-like content names in Interest and Data packets. Each NDN Node consists of the following components [1]:

- Content Store (CS)
- Pending Interest Table (PIT)
- Forwarding Information Base (FIB)
- Caching System consisting of a caching decision strategy and replacement policy

II. pCASTING

pCASTING is the name of a ***probabilistic CAching STrategy for the INternet of thinGs*** that considers dynamic attributes to calculate the caching probability of an incoming Data packet in a node. We used the following device and content related attributes:

- energy level (EN) normalized as $0 \leq EN \leq 1$
- cache occupancy (OC) normalized as $0 \leq OC \leq 1$
- residual freshness (FR) normalized as $FR = 1 - \frac{currentTime - t_s}{f}$ where t_s is the instant when the information was produced and f is the freshness in seconds (Data packets with negative freshness are not cached)

The Caching Utility Function F_u uses all parameters to compute the caching probability of a node. It can be written as follows:

- $F_u = \sum_{i=1}^{N_p} w_i g(x_i)$, where N_p is the number of parameters and the weights w_i assume a value such that $0 \leq w_i \leq 1$ and $\sum_{i=1}^{N_p} w_i = 1$. We weighted all parameters with a value of $\frac{1}{3}$ each.

III. Experiments

To evaluate the performance of the proposed pCASTING solution we consider a smart city scenario represented in Fig. 1. A group of sensors periodically generates data for context-aware services offered to consumers via an access point. We evaluated two simulation scenarios over ten independent runs each.

Scenario 1: (Results are represented in Fig 2.)

- Assess energy efficiency while ensuring good performance in terms of retrieval delay and collected data
- Low initial energy in forwarding nodes (simulation ends on energy depletion)
- Reference schemes: Caching Everything Everywhere (CE^2), a probabilistic scheme $P(0.5)$, a ***no caching*** scheme
- Performance metrics: cumulative distribution function (CDF) of the discharge time of forwarding nodes, cache hit ratio, consumers' received data packets, data retrieval delay (in seconds)

Scenario 2: (Results are represented in Fig 3.)

- Assess the efficiency of pCASTING from the network perspective
- High initial energy in all nodes (simulation ends after ten minutes)
- Reference schemes: $P(0.5)$, ***no caching***
- Performance metrics: number of Interest and Data packets, Consumer energy costs

IV. Conclusion

Our work explores in-network caching in named data wireless IoT networks, introducing the distributed caching scheme, pCASTING. This scheme adjusts caching probability based on battery energy level, cache occupancy, and Data packet freshness. Simulation results confirm the solution's effectiveness, reducing node energy consumption and ensuring low content retrieval delays. The simplicity of pCASTING's caching probability computation allows for easy modification by adding additional parameters.

References

[1] L. Zhang et al., "Named Data Networking (NDN) Project,"PARC, Tech. Rep. NDN-0001, October 2010.

Fig. 1: Simulation Scenario

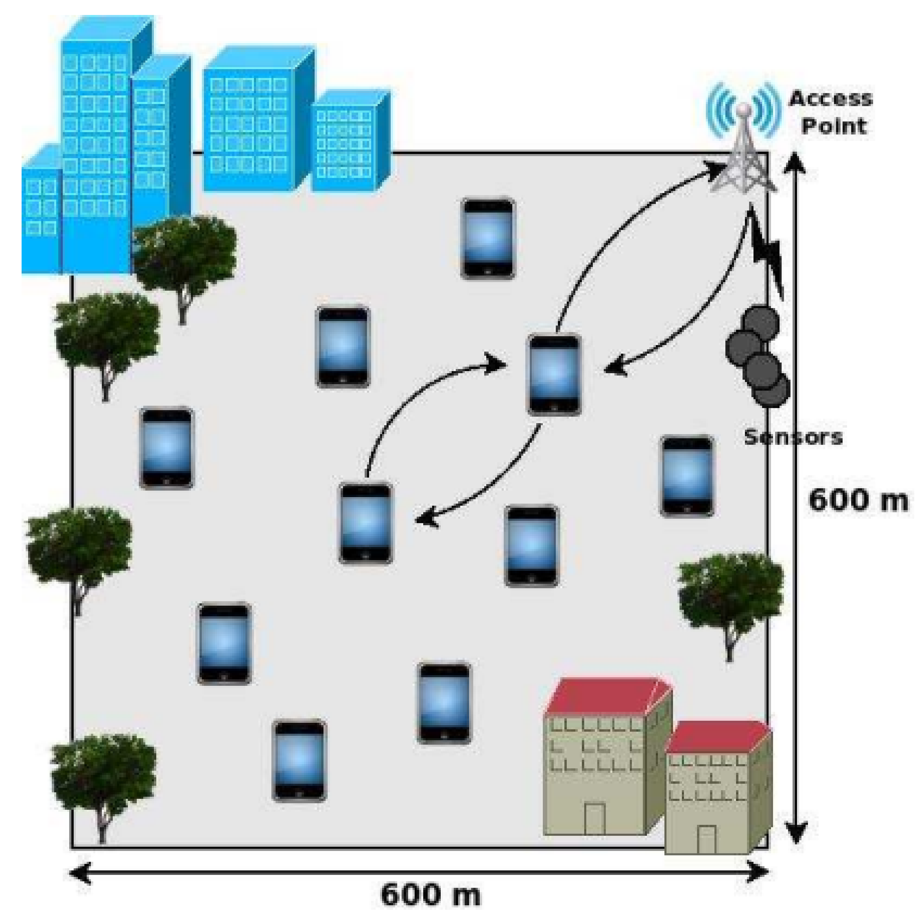
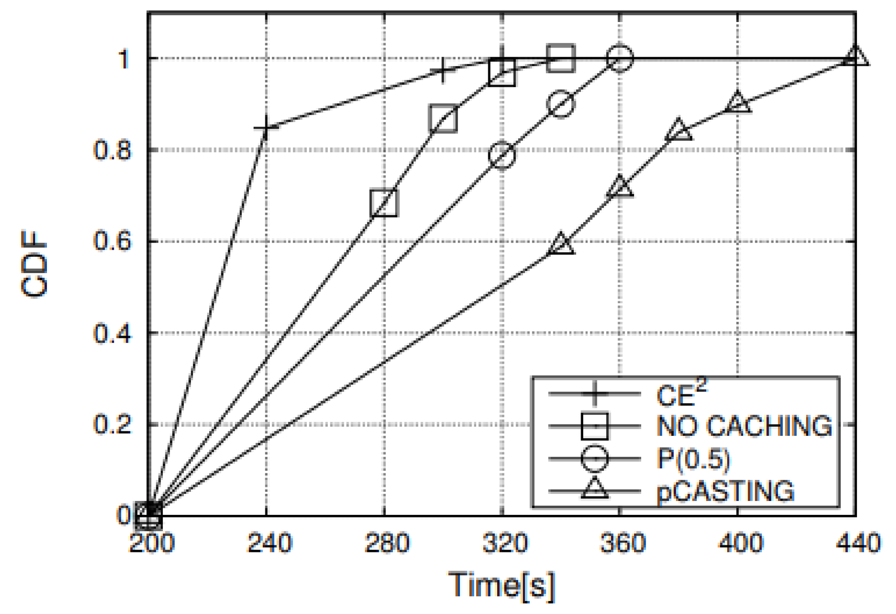


Fig. 2: Results of the first experiment



Data dissemination performance metrics

Metric	CE²	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

Fig. 3: Results of the second experiment