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Distributed Caching and Femto Base Station Cooperation for Fast Content Delivery

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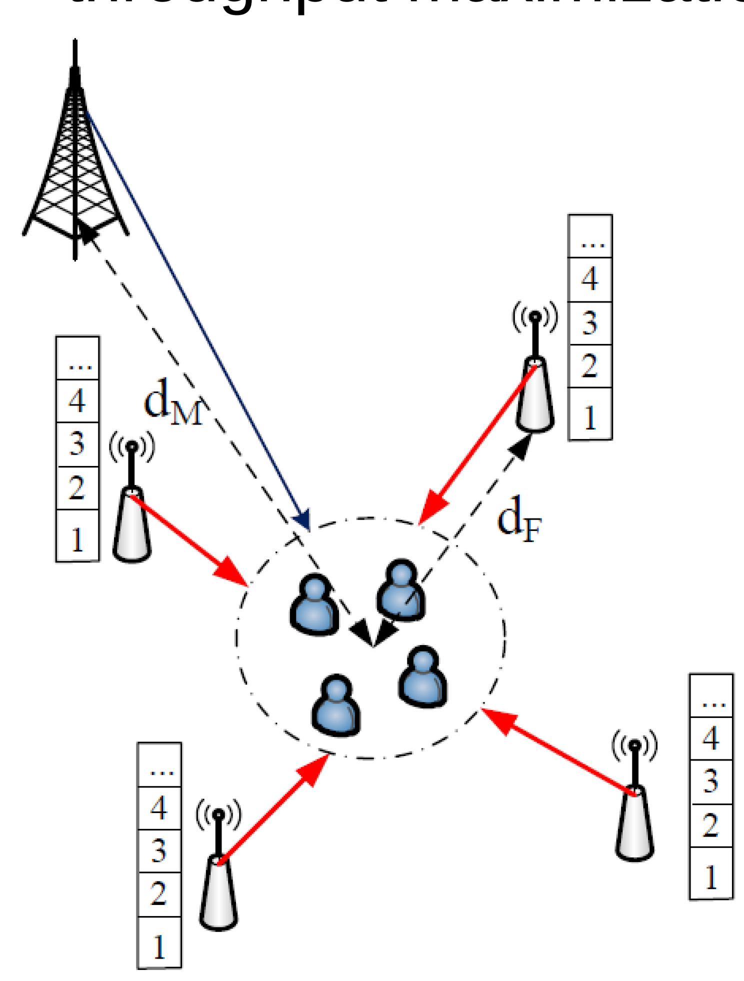
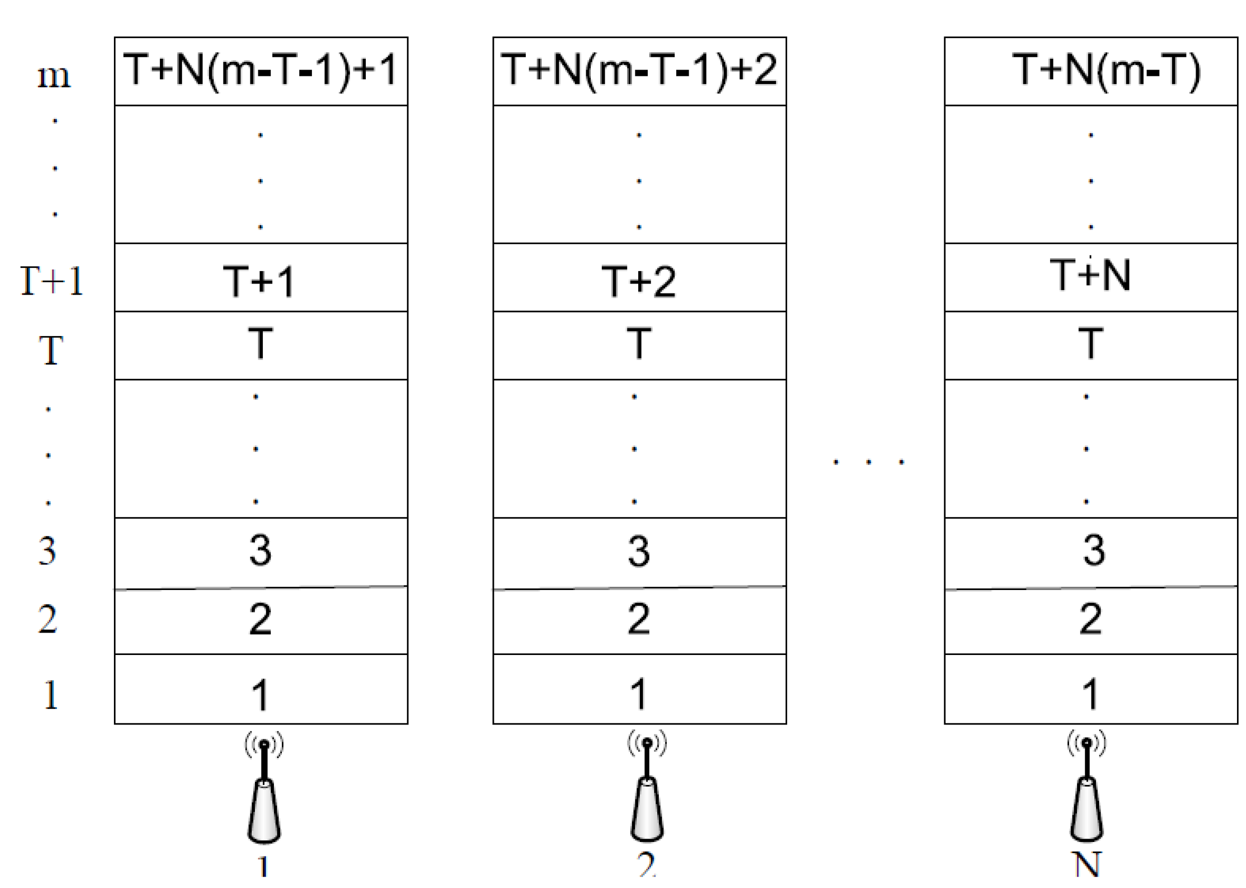
Introduction and Motivation

- **Distributed caching of content in femto-BSs (FemtoCaching)**
  - Bring content closer to end users, reduce backhaul cost and delay
- **Base station cooperation (CoMP)**
  - Multiple BSs jointly serve end users with MRT or ZFBF, increase reliability or data rate
- **Cache-driven femto-BS cooperation**
  - Femto-BSs that have the requested content in their caches dynamically forms a cooperation cluster
  - Interdependence between the caching strategy and the physical layer coordination
    - ✓ Cache different content in nearby BSs to maximize the cache hit ratio
    - ✓ Cache the same content in nearby BSs to enable CoMP, e.g., to achieve multiplexing gains
  - Optimal caching strategy depends on content popularity, available cache size, network topology, etc

Zero-Forcing BeamForming (ZFBF)

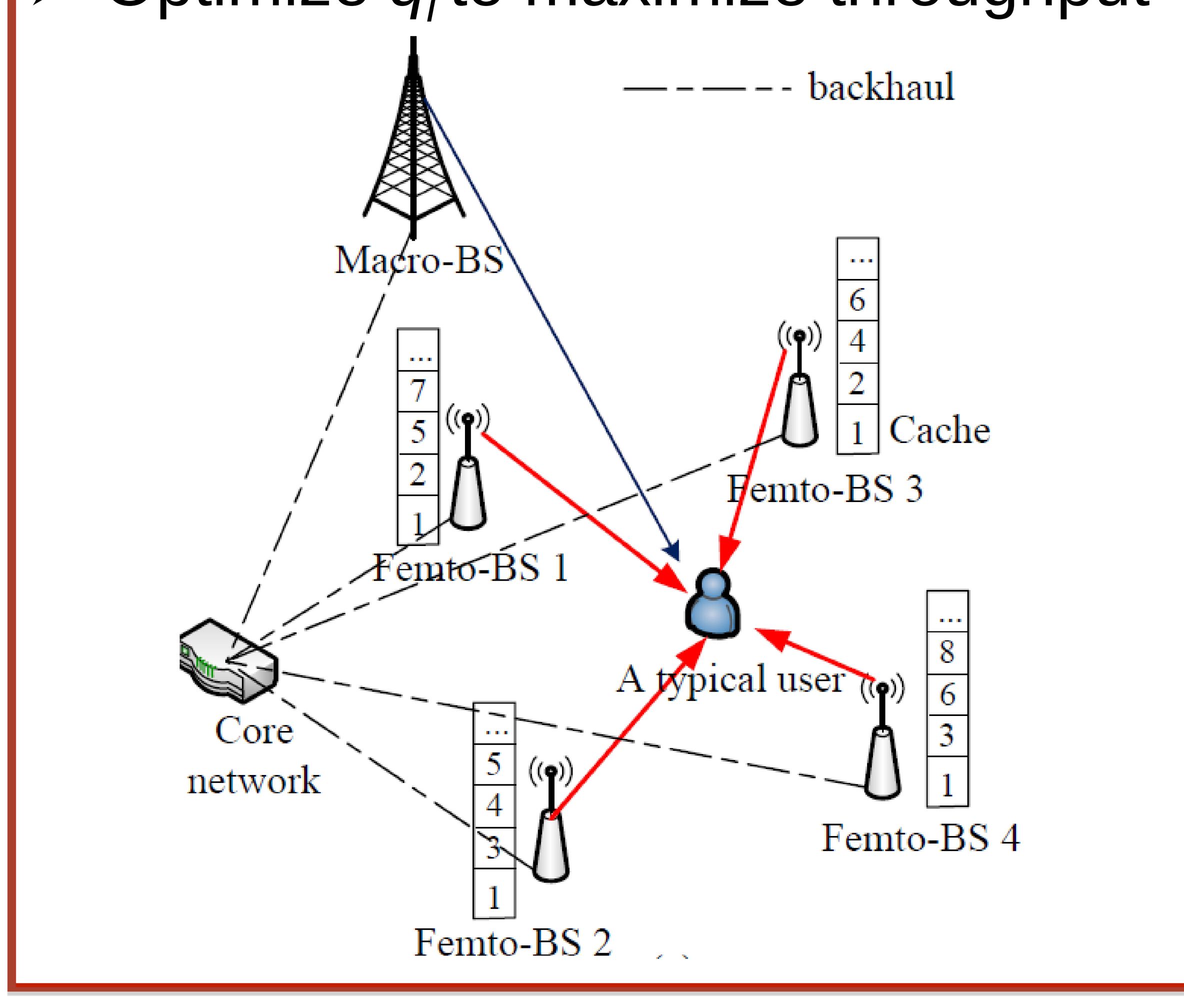
- Providing multiplexing gain by threshold-based caching and ZFBF
- Consider *M* files (ordered by popularity), *N* femto-BSs each with cache size *m*, *K* users, one marco-BS (lower rate)
- In femto-BSs, we cache *N* copies of the most popular *T* files, and one copy of files *T+1* to *T+N(m-T)*. The rest of files are stored in marco-BS.
- Optimize *T* to tradeoff multiplexing gain and cache hit ratio for throughput maximization





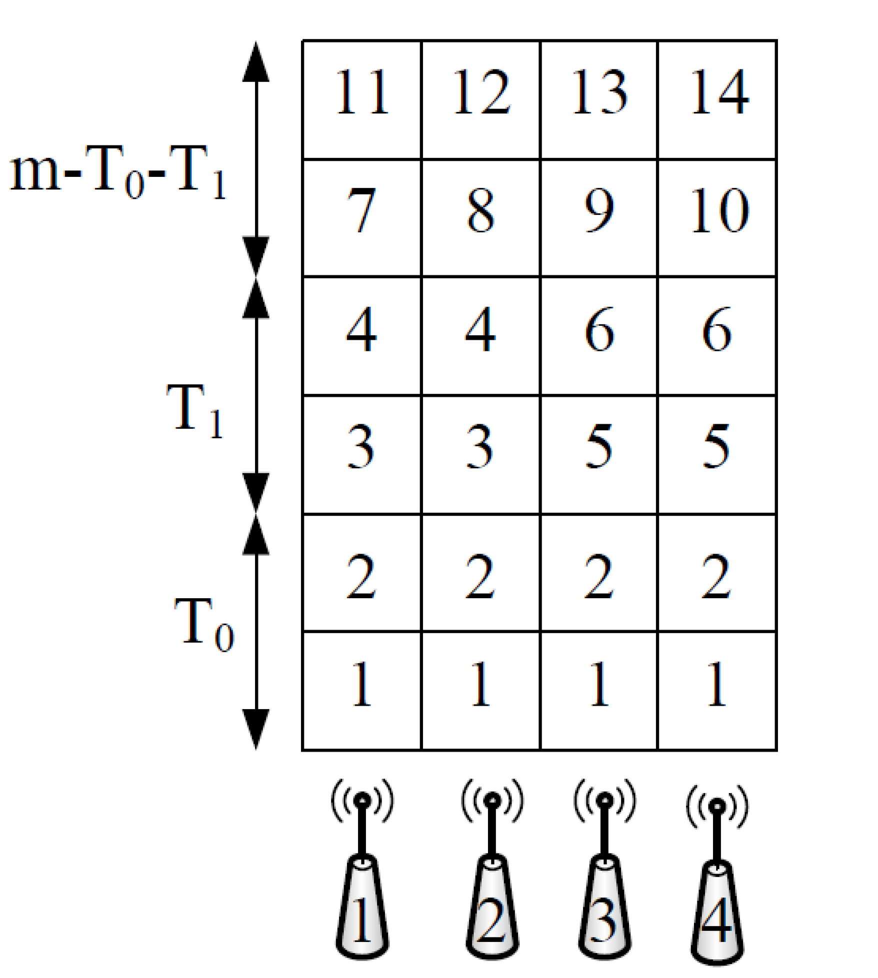
Maximal Ratio Transmission (MRT)

- Providing diversity gain by randomized caching and MRT
- Each femto-BS cache file *i* with probability q_i subject to $\sum_{i=1}^{M} q_i = m$
- Cluster size (diversity) for file *i* is binomial distributed with mean Nq_i
- Optimize q_i to maximize throughput



Extensions

- A joint MRT-ZFBF scheme
- ZFBF with multi-thresholds offers a finer granularity for controlling the trade-off



Simulation results

- We assume *M* = 1000 and Zipf popularity distribution with parameter *s*, $p_i \propto i^{-s}$, and consider the result for ZFBF with a single threshold.
- For a non-skewed file popularity (small *s*), the optimal threshold *T** is near 0. We should only cache a single copy of the files to increase the cache hit ratio.
- For a skewed file popularity (large *s*), *T** is near *m*, we should cache multiple copies of the most popular files to provide multiplexing gains.

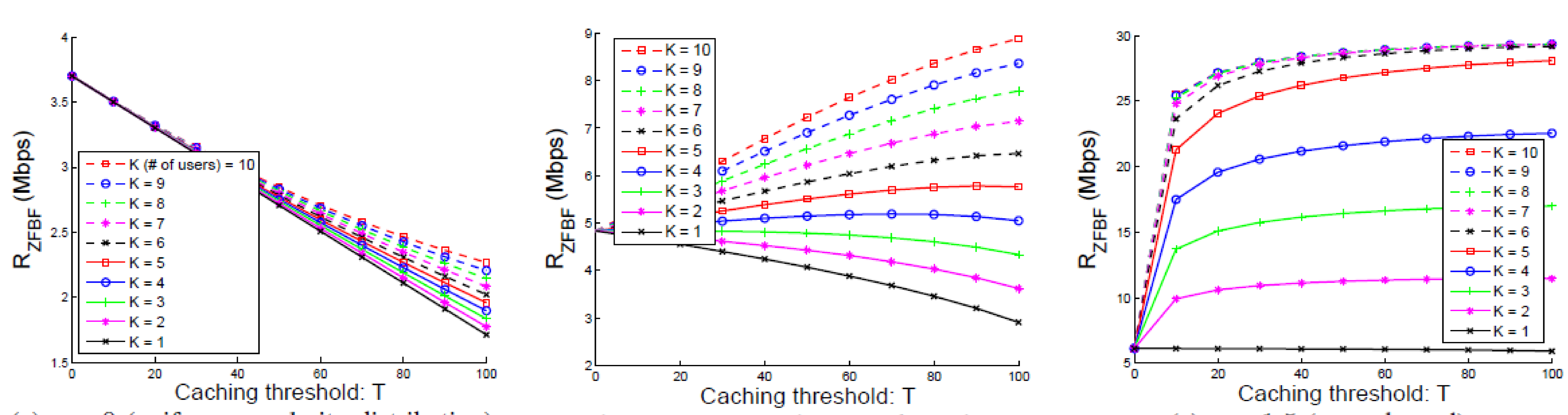


Fig. 1: Performance of the system under ZFBF with $N = 5$, $m = 100$.

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