Dynamic Online Storage Allocation for Multi Content Dissemination in IMCNs

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Abstract

We consider a two-tier hybrid mobile network in which the data plane consists of store and forward routing through an intermittently connected mobile network, and the control plane consists of an always-on infrastructure-based wireless network. We formulate and address from a theoretical perspective the fundamental problem of how to dynamically allocate storage in the form of helper nodes in an online fashion in such a network when there are multiple files to be disseminated. The goal is to maximize a utility function that is a parameterized combination of fairness and efficiency in terms of the satisfied demands for each file by a given deadline. We show that for a homogeneous contact process with an arbitrary inter-contact duration distribution, the optimum solution can be obtained by modeling the problem as a Markov Decision Process that can be solved in polynomial time.

Introduction

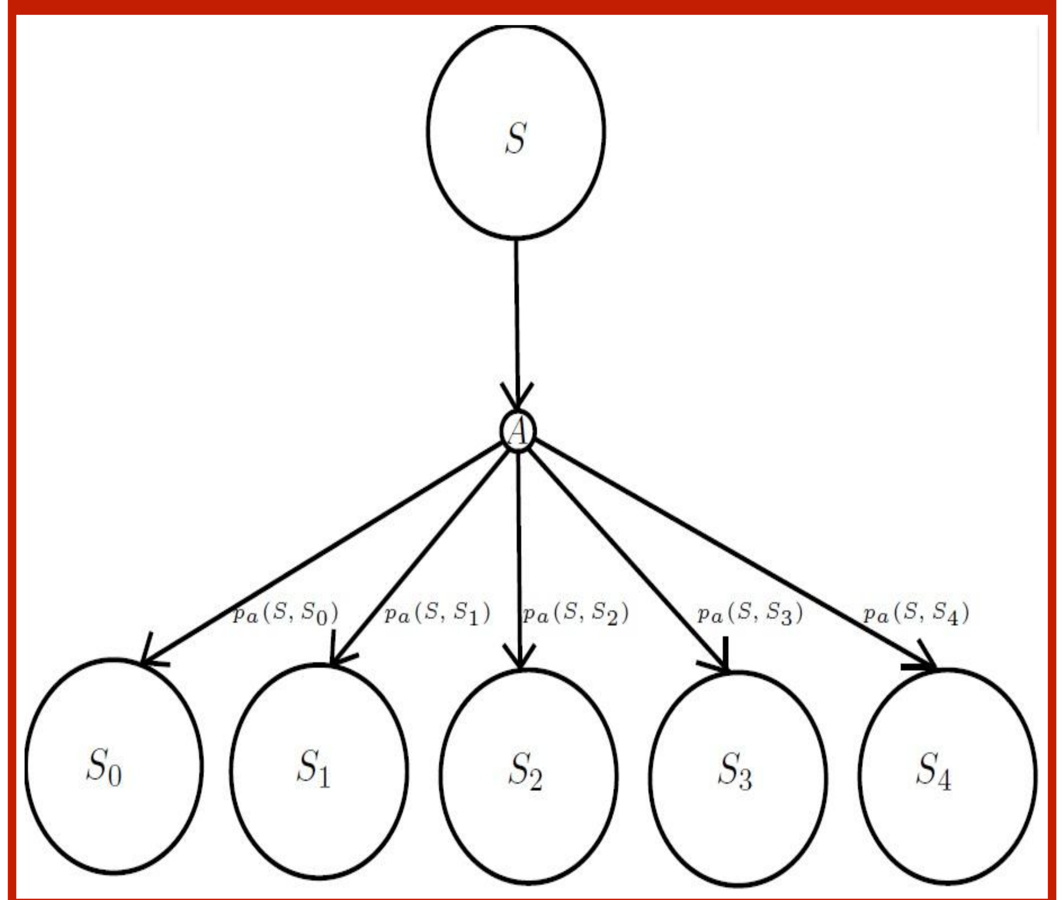
- There is an increasing interest in exploring the design of large-scale intermittently connected mobile networks where information is exchanged primarily through local encounters.
- we consider a two-tier hybrid wireless network consisting of a data plane and a control plane.
- The data plane consists of nodes that are mobile and intermittently connected. They stores and forward data packets.
- The control panel has the global information and decides which node has should help which file.

- Nodes may up to three different roles:
  - Source nodes
  - Demanding nodes
  - Intermittent nodes

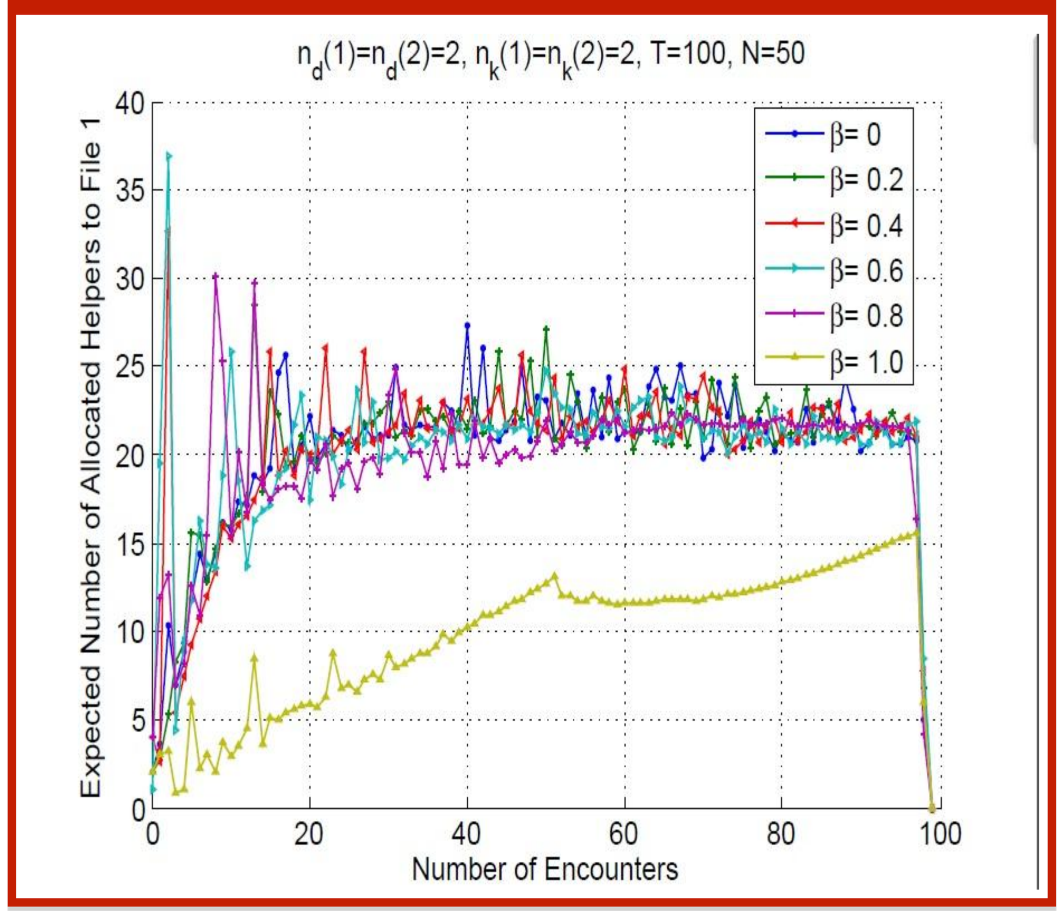
Given a deadline we investigate the problem of how best to utilize intermediate nodes to (called helper nodes) to maximize the satisfied demands by the deadline.

- The centralized server receives updated estimates of the current stat and respond in an online fashion by assigning each intermediate node an specific file.

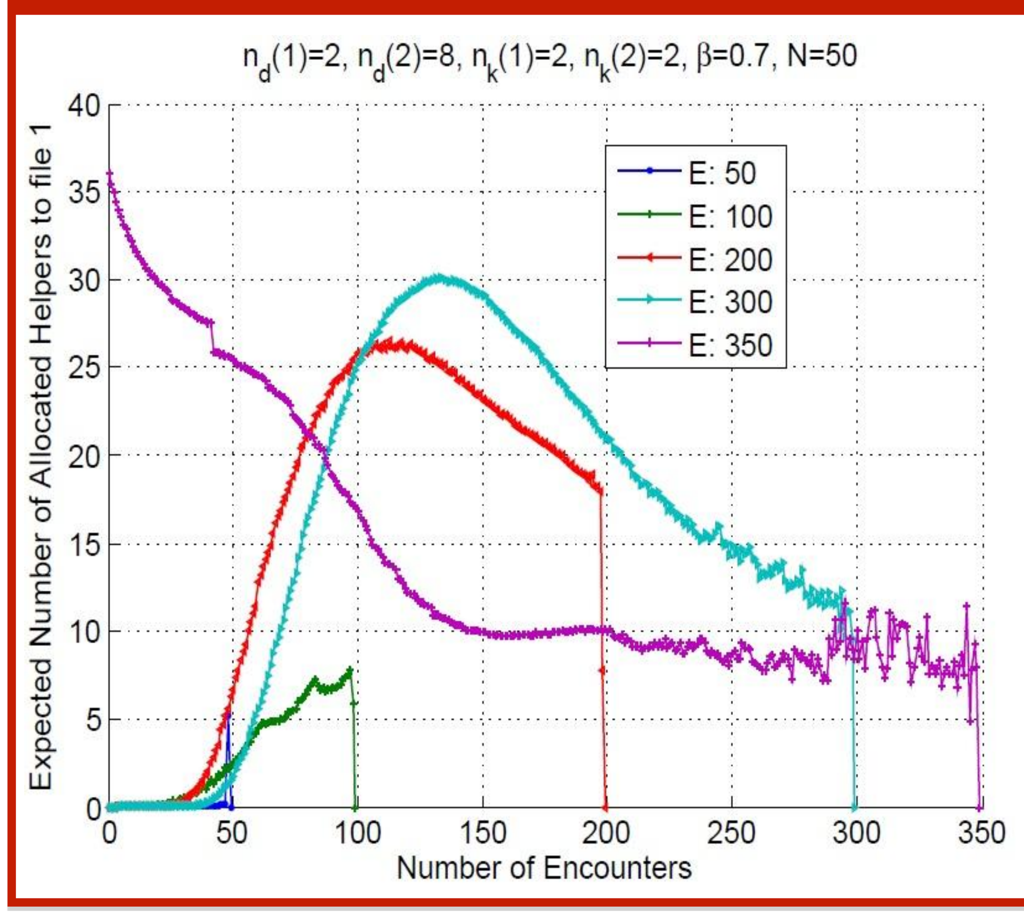
State Transitions



Expected Actions



Expected Actoins

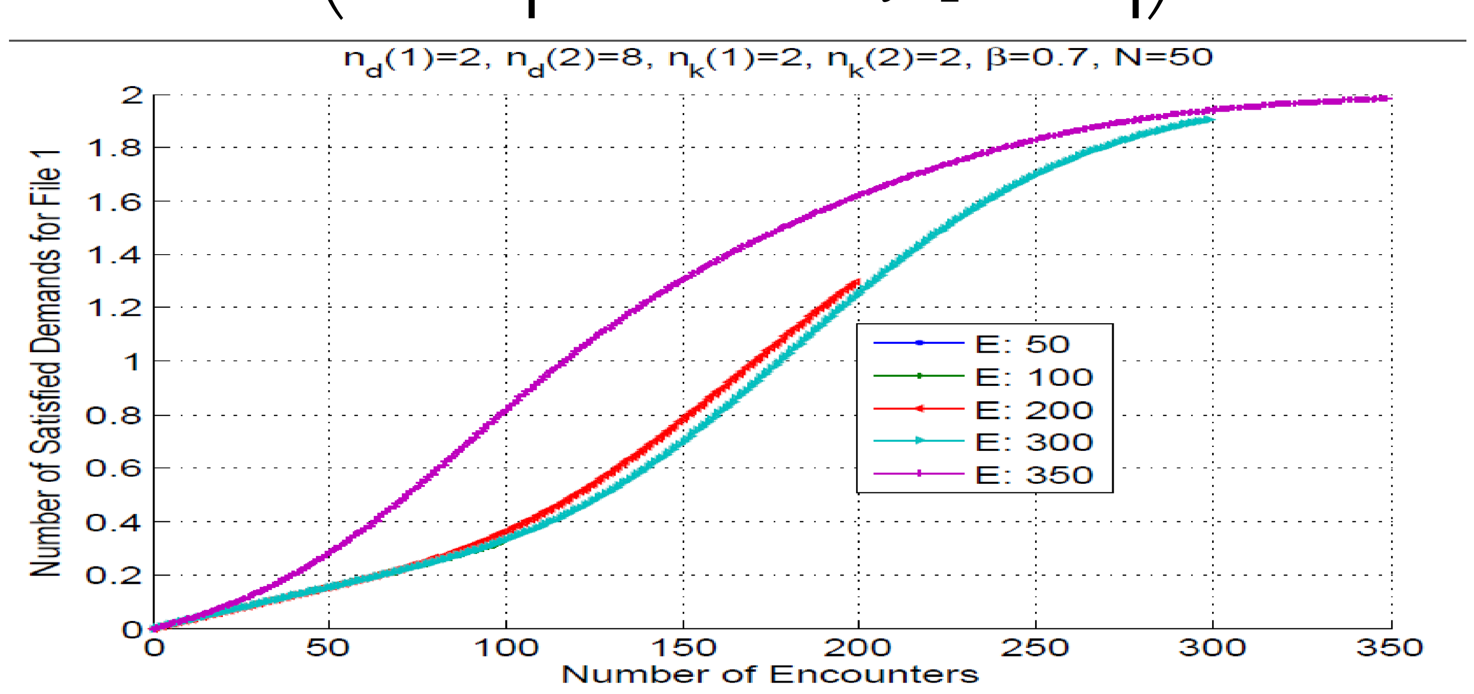


Model & Results

- The goal is then, given a starting state, to find out policies that maximize the total finite horizon reward till the end of time (finite horizon).
- At a given state $\{c_d(v,e), c_h(v,e)\}_1^V, e\}$for each file v, there are $c_h(v,e)$ helper nodes carrying it after e encounters. The action at such a state is defined as vector $a_S = (a_1, \ldots, a_V)$ denotes the number of helper nodes.
- An MDP problem ρ is represented by a 4-tuple $\{S, A, P(.,.), R(.)\}$ where:
  - S: state space
  - A: set of actions
  - $P_a(S,S')$: is the transition probability of moving form one state to another given action a
  - $R(S)$: is the reward collected when state space S is reached.

- The utility function used:
- $U(c_1, \ldots, c_V) = \beta \left(\frac{\sum_{v=1}^{V} c_d(v)}{\sum_{v=1}^{V} n_d(v)}\right)^2 -$

$$(1-\beta)\left(\sum_{v=1}^{V}\left|\frac{c_d(v)}{n_d(v)} - {}^1/_V \sum_{v=1}^{V}\frac{c_d(v)}{n_d(v)}\right|\right)^2 - \beta$$



Conclusion

- In one encounter it allocates most of the helpers to one file and in the next encounter it does the vice versa. As the number of helper nodes evolve for both files the optimum policy becomes more stable.
- The main reason of fluctuating between two extremes rather than assigning equal share to both, is: If a specific node i is assigned to help file 1 but meets with a node with file 2, it is not an effective encounter, i.e. no files can be transferred. Therefore, by allocating most of the nodes to one file, the optimum allocation increases the chance of having an effective encounter.