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# 11<sup>th</sup> **ERDT Conference** on Semiconductor and Electronics, Information and Communications Technology and Energy

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# Envision, Enable and Empower Smarter and Resilient Societies

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## ANALYSIS OF HIERARCHICAL DHTs UNDER CHURN

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### ABSTRACT

In this work, we present a performance analysis of structured peer-to-peer (P2P) networks under churn. Through simulation of Hierarchical Distributed Hash Tables (DHTs), we show the behavior of these systems when highly mobile nodes are prevalent.

Structured P2P network is a type of P2P overlay formed on top of the Internet Protocol (IP) network. Its tightly controlled topology and its routing and location mechanism make it efficient in locating items in the network [1]. Structured overlays use Distributed Hash Tables (DHTs) for deterministically placing content in the node topology. Hence, they are sometimes called DHTs. DHTs can be classified based on the overlay node hierarchy [2]; they can be flat DHTs or hierarchical DHTs. Flat DHTs (FDHTs) organize nodes only in one level or layer. While hierarchical DHTs (HDHTs) cluster nodes into multiple levels or layers.

Recent FDHTs perform poorly under churn, which is the process of node arrival and departure inherent in mobile and wireless networks. These FDHTs suffer from routing performance degradation; they have significantly lower lookup success ratios, longer lookup latencies and higher bandwidth utilizations. With this, they cannot provide a stable and efficient routing and location mechanism for P2P applications.

Conversely, an HDHT uses independent clusters for better resiliency and efficiency compared to an FDHT. However, recent HDHTs have not been evaluated intensively under high churn. Thus, we provide an initial analysis and comparison of two HDHTs, the Chord-Chord HDHT and the Chord-Kademlia HDHT.

The OMNeT++ Simulator with the OverSim Framework is utilized for the simulation of the HDHTs. The two HDHTs are simulated with and without churn under varying factors, specifically the total population and the node lifetime. The total population pertains to the number of nodes available in the network. The node lifetime pertains to the average time a node stays before leaving the network. HDHT routing performance is then analyzed with respect to the success ratio, the percentage of completed lookups out of the total requested lookups.

Figure 1 shows the Success Ratio with respect to the Total Population. When HDHTs have no churn, they experience no lookup failures and have 100% success ratios. When HDHTs are subjected to high churn, they experience lookup failures due to request timeouts or due to requests returned with incorrect values. When the total population is increased, success ratios of HDHTs under churn decrease due to more timeouts. At higher population, resolving node's location is slower since the request is forwarded to more hops and thus more prone to error since the request may pass unreliable mobile nodes. In addition, Chord-Kademlia has better fault tolerance due to the Kademlia implementation's secure routing table update policy and bigger routing table size.

Figure 2 shows the Success Ratio with respect to the Node Lifetime. HDHTs without churn are not affected when node lifetime is varied since all nodes are reliable and do not leave. Like in Figure 1, both HDHTs under churn have similar trends. When the node lifetime is increased (churn is decreased), lookup failures are less likely to occur.

To better understand the effects of churn to HDHTs, their performance may be analyzed with respect to other metrics such as lookup latency and bandwidth consumption. HDHTs can be evaluated under other conditions such as varying maintenance interval, varying reliable population ratio and varying cluster size.

**Keywords:** Churn, DHT, HDHT, mobile network, OverSim, P2P

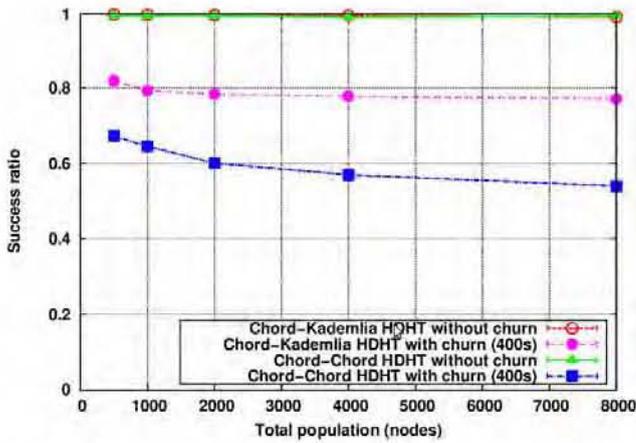


Figure 1. Success Ratio at Varying Total Population

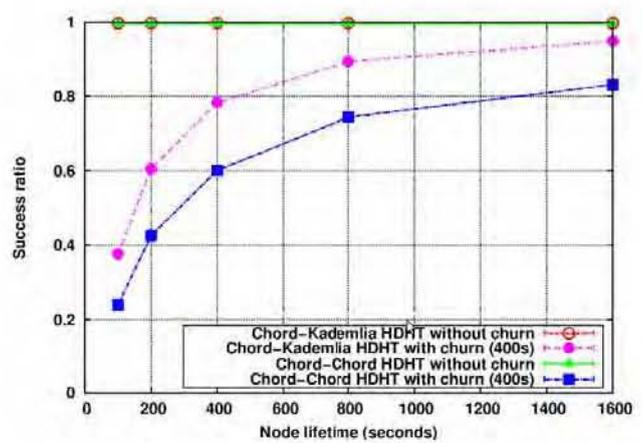


Figure 2. Success Ratio at Varying Node Lifetime

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