Opportunistic Prefetching In Localized Internet Of Things (IoT)

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Introduction
- In IoT applications, devices exchange information without human intervention.
- Opportunistic prefetching in IoT enables acquisition of data in anticipation, when two devices come in contact.
- The Prefetched data is cached on the IoT device for use when needed by the applications.

Objective
- Develop a scheme for opportunistic prefetching of real-time data in IoT environment.
- Demonstrate usability of the developed scheme in real life applications.

Implementation
- Periodic broadcasts initiate opportunistic connections. A caching technique is important for efficient storage of data before prefetching.
- We employ a Least Frequently Used Caching strategy where we assign priority based on how frequently a prefetched data is used.
- Least priority data is replaced with newly prefetched data when the cache is full.

Prefetching: Prefetch data only if it is important. Importance is decided by a Naïve Bayes predictor. We demonstrate this scheme by an android application that:
1. Prefetches fitness data from others.
2. Uses this data to:
   - Improve fitness by competition.
   - Find traffic in park / subway.

Naïve Bayes predicts using cache data:
\[
P(\text{Prefetch} | \text{Param}) = \frac{P(\text{Param} | \text{Prefetch}) \times P(\text{Prefetch})}{P(\text{Param})}
\]

Find Users For Fitness Competition:

<table>
<thead>
<tr>
<th>Devices</th>
<th>Prefetch</th>
<th>Non Prefetch</th>
</tr>
</thead>
<tbody>
<tr>
<td>S devices</td>
<td>1 ms</td>
<td>122 ms (~Average)</td>
</tr>
<tr>
<td>N devices</td>
<td>1 ms</td>
<td>Time to retrieve sensor data (N Devices)</td>
</tr>
</tbody>
</table>

Detect Traffic:

<table>
<thead>
<tr>
<th>Device</th>
<th>Prefetch</th>
<th>Non Prefetch</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Devices</td>
<td>1 ms</td>
<td>122 ms (~Average)</td>
</tr>
<tr>
<td>N Devices</td>
<td>Time (Route across zones)</td>
<td>Time (retrieve sensor data from N Devices)</td>
</tr>
</tbody>
</table>

Is Park Busy?: Dynamic steps from all devices deduce how busy is a park/subway.

With scattered traffic, the entire area is divided into zones of radius 20 m each. The border nodes are marked as special nodes and are responsible to get data from other zones spanning multiple hops.

Performance & Results

Prefetching data in advance as described earlier saves significant amount of time compared to retrieving data at time of need.

Find Users For Fitness Competition:

Sample Traffic Detection Simulation:

Graph represents the traffic calculated by a device with 2 surrounding devices simulating different zones by using sample simulation data.

Conclusion & Future Work
- Our results clearly indicate that prefetching saves considerable amount of time. Also, the cached data reduces dependency on network.
- This logic can be extended to many other areas including:
  - Find regions with scattered populations during disaster recovery.
  - Locate busier night clubs / bars.
  - Easily locate places with more people to setup food stalls / trucks.
- Our future work will extend the application beyond localized IoT with enhanced sensor capabilities. We will also support compatibility with various network standards such as Wi-Fi direct.

References