Layered Video Communication in ICN Enabled Cellular Network with D2D Communication

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Outline

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• Conclusion
• Wireless part of the network is always considered as the bottle neck

• Demand of the bandwidth thirsty applications is increasing more rapidly than the growth of the wireless network capacity

• Modern UEs encouraging us to use it for sophisticated applications i.e., D2D communication
  • Larger memory
  • Equipped with ability of powerful processing

• ICN/CCN, a future Internet architecture, enables all the networking devices to play more important role
• In this paper, we propose to provide the requested video to users from other users cache, using D2D link

• Our objective is to reduce the download delay for the users’ requested video

• We formulate the problem as a matching game in which the resources are assigned to the users in the uplink period
CCN is a new internet structure that changes current IP structure as:

“What” instead of “where”

Users send interest packet and CCN nodes sends back data chunk either from its local content store or request it from content provider

CCN nodes store a copy of the data chunk that passes through

Cache is one of the most important resource of a
Background: Scalability in Video Streaming

Bitrate delivered to viewer determined by player and network heuristics
System Architecture

- UEs
- BS
- Interference
- Transmission
- UE with Cache

(a) (b) (c) (d)
Communication Scenario

1. Start
2. Needs data
3. Found in own cache?
   - Yes: Use it
   - No: BS found the requested content in the vicinity?
     - Yes: Inform the sender device
     - No: Provided the content from BS cache or from content provider
       - Allocate resources and communicate
       - End
Problem Formulation

• For RB allocation we use binary variable $x_{mn}^k$:

$$x_{mn}^k = \begin{cases} 
1, & \text{If D2D pair in group } g \text{ is assigned RB } k \\
0, & \text{otherwise}. 
\end{cases}$$

• D2D transmission rate of a UE

$$R_{nm}^k(X, P) = W^k \log \left( 1 + \sum_{\substack{n' \neq n, \\ m' \neq m}} x_{n'm'}^k h_{nm}^k P_{nm}^k + \sigma^2 \right)$$
• Total transmission rate

\[ R_n(X, P) = \sum_{m,k} W^k x_{nm}^k R_{nm}^k(X, P) \]

• Delay Analysis

\[ D_n(X, P) = \frac{b_{i,l}^m}{2R_n(m, k) \left( R_n(m, k) - b_{i,l}^m \right)} \]
OPT-1:

\[
\text{minimize}_{x} \sum_{n \in \mathcal{N}} D_n,
\]

subject to:

\[
R_m(\mathbf{X}, \mathbf{P}) \geq R_{m,\text{min}},
\]

\[
P_{nm}^k \in \mathcal{P}_n = \{0, P_{n,\text{max}}\}; \ \forall m, n, k,
\]

\[
x_{nm}^k = \{0, 1\}, \ \forall m, n, k,
\]

\[
\sum_{k \in \mathcal{K}} x_{mn}^k \leq 1, \ \forall m, n,
\]

\[
x_{mn} = \{0, 1\}, \ \forall m, n,
\]

\[
\sum_{n \in \mathcal{N}} x_{mn} \leq 1, \ \forall m,
\]

\[
\sum_{m \in \mathcal{M}} x_{mn} \leq 1, \ \forall n.
\]
Algorithm 1 Resource Allocation to cellular and D2D users

1: Initialize: $N^\text{req}_x, N^\text{accepted}_x, N^\text{rejected}_x$
2: **Stage I:** Discovery and utility computation
3: UE sends request to BS to get content.
4: BS searches the requested content in VC and find M
5: BS broadcasts its sub-channels and M to requesting UEs
6: Requesting UEs compute its utility values and build based on (3)
7: **Stage II:** Matching operation to find stable matching
8: Each UE $n$ sends a request for network resource $x$ $(m,k)$ to BS, $x = \arg \min(D_n(x))$
9: **Base station do:**
10: Updates set of requested UEs $N^\text{req}_x$
11: Computes utility values and build $\succ_x$ based on (6).
12: Update accepted list following (6):
13: if $n$ satisfy (6) then
14: $N^\text{accepted}_x \leftarrow \arg \min(D_n(x))$ using the Hungarian matching algorithm
15: else
16: $N^\text{accepted}_x \leftarrow n$
17: end if
18: BS informs $N^\text{rejected}_x$. This $N^\text{rejected}_x$ will be considered in the next uplink transmission period.
19: Go back to step 2
20: Outputs: $\alpha^*$ and Stable matching $\mu^*$ [6]
Performance Evaluation

- Download delay for different number of UEs

- Download delay for different number of RBs
• Download delay for different number of content nodes
Conclusions

• In this paper, we present resource allocation to the CU and D2D pair in the uplink transmission period.

• UEs with memory can provide other users requested content, via D2D link.

• We proposed matching game based approach to solve the resource allocation problem.

• Objective of the resource allocation is to reduce the download delay of the requesting UEs.

Thank You !!!