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Paper Summary

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Contents

1 Information centric networking

1.1 A Survey of Information-Centric Networking

The work in [1] provides an insight into the Information-Centric Networking (ICN). The authors present the advantages of the ICN approach and give an overview of four ICN architectures. While these approaches differ with respect to the implementation details, they share many assumptions, and architectural properties. The aim of all these approaches is to develop a network architecture that is better suited for efficiently accessing and distributing content and that better copes with disconnections and disruptions.

The main abstraction of ICN is the named data object (NDO). An NDO keeps its name, and thus its identity, regardless of its location and regardless of how it is copied and stored. For NDO, a verifiable binding between the object and its name (name-data integrity) is important, so that a receiver can be sure to receive data that actually represent the named object.

The ICN approach presents many advantages compared to the state-of-the art IP-based routing. It provides scalable and cost-efficient content distribution. Furthermore it provides persistent and unique naming. Today's networks locate objects after DNS resolution. These bindings can easily break when an object is moved. The ICN approach overcomes this problem with unique naming of NDOs. ICN has a different security model than the state-of-the art networks. It provides name-data integrity of NDOs independent of the source. In ICN networks a moving client just continues to issue requests for NDOs on a new access. Requests on the new access can be potentially served from a different source instead of having to maintain a connection to the previous one.

Furthermore, the paper provides an overview of different ICN approaches. It introduces the reader to Data-Oriented Network Architecture (DONA), Content-Centric Networking (CCN), Publish-Subscribe Internet Routing Paradigm (PSIRP) and Network of Information (NETINF). Then it compares the design choices and discusses the different approaches on the aspects of naming and security, API, name resolution and routing, caching, transport, and mobility.

1.2 Networking named content

One of the most popular ICN approaches is the Content-Centric Networking (CCN) presented in [2]. There are two types of packets in CCN, Interest and Data. A consumer asks for content by broadcasting its Interest over all available faces. Any node hearing the Interest and having data that satisfies it can respond with a Data packet. Data is transmitted only in response to an Interest and consumes that Interest. The CCN packet forwarding engine has three main data structures: the FIB (Forwarding Information Base), CS (Content Store / buffer memory) and PIT (Pending Interest Table). The FIB is used to forward Interest packets toward potential source(s) of matching Data. The CS stores received data as long as possible for sharing it with other users in the network. The PIT keeps track of Interest forwarded upstream towards content source(s), so that returned data can be sent downstream to its requester(s). Only Interests are routed towards sources, generating entries in the PIT of each intermediate node. Data, on the other hand, does not have to be routed. When a node of the network receives data, it knows from the PIT where to send it next.

The paper also provides an insight into the naming of objects in CCN networks. Although naming conventions are not part of basic CCN transport, they are an important element of application design. The authors of the paper present an example of a naming tree for an application that wants to display the most recent version of a video and show, that it can be designed to take advantage of the relative retrieval features of Interest packets.

Furthermore the paper gives information about the security in CCN networks. CCN is built on the notion of content-based security: protection and trust travel with the content itself, rather than being a property of the connections over which it travels. The primary means of controlling access to CCN content is encryption. CCN does not require trusted servers or directories to enforce access control policies; no matter who stumbles across private content, only authorized users are able to decrypt it. Decryption keys can be distributed along with their content, as CCN Data blocks. Name conventions, encapsulated in programmer-friendly libraries, can make it easy to find the decryption key necessary for an authorized user to decrypt a given piece of content.

Finally the authors implement a prototype CCN network stack, and demonstrate its usefulness for both content distribution and point-to-point network protocols.

2 Device to device communication

2.1 Device to device collaboration through distributed storage

Device-to-device (D2D) communications can be exploited to drastically increase the capacity of cellular networks for video transmission [3]. Users can cache popular video files and - after receiving requests from other users - serve these requests via D2D localized transmissions; the short range of the D2D transmission enables frequency reuse within the cell.

This idea is motivatedby two key observations. Firstly video has a high degree of content reuse, i.e., a few popular files are requested by a large number of users and secondly smartphones and tablets have significant storage capacity that is rapidly growing and typically underutilized.

For the model, the authors consider a cell within a cellular network. For simplicity they assume that the cells are square and neglect inter-cell interference, so that they can consider one cell in isolation.

Each user in the cell requests a file randomly and independently from a library. The size of the library is a function of the number of users n, since a larger number of users covers a larger set of files they could be interested in. They assume that the various file popularities are distributed as per the Zipf distribution.

They introduce γ_r, which characterizes the Zipf distribution by controlling the relative popularity of files. A large γ_r means a concentrated distribution. The results of the simulation show, that for a larger γ_r there exist more non interfering D2D links. Furthermore, they conclude, that device-to-device video sharing, enabled by local storage can bring tremendous benefits in future wireless systems.

3 Network coding

3.1 Network coding for the internet and wireless networks

Paper [4] introduces network coding (NC) for wireless networks. The potential advantages of NC over routing include resource (bandwidth, power) efficiency, computational efficiency, and robustness to network dynamics.

In a network with a bottleneck it may be possible to increase throughput by using NC and mixing two streams together. By taking some linear combination of the two streams the bottleneck may reduce the total number of transmissions. If the stream can be decoded before or when they reach their final destinations, this usage of NC will increase throughput. In further examples the authors show that using NC in specific situations can minimize the energy per packet. Through clever choices of NC less transmissions are required for the receiver to get the data. Furthermore the delay can be reduced by using NC in a wireless network. Using NC in specific situations result in less intermediate nodes between the source and a receiving user.

Since NC provides various benefits in theory, the authors discuss how practical NC can be implemented in real networks. They give an introduction to random coding, packet tagging, and buffering. As a conclusion they say, that building network coding into IP-level routers in the internet is unlikely to be practical in the near future. However in overlay networks it is quite feasible. In some communication tasks they see network coding as a way to potentially increase the throughput, i.e. for downloading files or in wireless mesh networks.

3.2 Xors in the air

In [5] the authors propose COPE, a new architecture for wireless mesh networks, which inserts a coding layer between IP and MAC layers. It takes the ideas discussed in [4] where NC is shown to be advantageous in terms of increasing network throughput. Additionally COPE takes advantage of the broadcast nature of the wireless channel.

COPE sets the nodes in the network in promiscuous mode, makes them snoop on all communications over the wireless medium and store the overheard packets for a limited period of time. In addition, each node broadcasts reception reports to tell its neighbours which packets it has stored. In COPE, the key question for users in the network is what packets to code together to maximize throughput. A node may have multiple options to improve throughput, but it should aim at maximizing the number of native packets delivered in a single transmission, while ensuring that each intended next hop has enough information to decode its native packet. In the absence of deterministic information, COPE estimates the probability that a particular neighbour has a packet as the delivery probability of the link between the packet's previous hop and the neighbour.

The results from an experiment of a 20-node wireless test bed to study both the performance of COPE and the interaction of network coding with the wireless channel and higher-layer protocols show, that the throughput, that varies depending on the radio of download traffic to upload traffic at the gateway, can be increased from 5% to 70%.

A multi hop wireless network must have certain characteristics so that COPE can be used. The nodes in the network need to have some free storage, due to the need to store recently heard packets for future decoding. They need to have omni-directional antennas to exploit the wireless broadcast property for opportunistic listening. Furthermore, COPE does not optimize power usages and assumes the nodes are not energy limited.

3.3 Network coding for distributed storage systems

Paper [6] introduces the use of NC in distributed storage systems.

Storing data using an erasure code, in fragments spread across nodes, requires less redundancy than simple replication for the same level of reliability. However, since fragments must be periodically replaced as nodes fail, they introduce the notion of regenerating codes, which allow a new node to communicate functions of the stored data from the surviving nodes. The authors show that, there exist erasure codes that can be repaired without communicating the whole data object.

Two redundancy maintenance schemes called minimum-storage regenerating (MSR) code and minimum-bandwidth regenerating (MBR) code are introduced, evaluated and compared to the ”hybrid strategy”. In the ”hybrid strategy”, one special storage node maintains one full replica in addition to multiple erasure coded fragments. The node storing the replica can produce new fragments and send them to newcomers.

Compared with the ”hybrid strategy”, MBR codes offer slightly lower maintenance bandwidth and storage and a simpler system architecture. MSR codes, offer a simpler symmetric system design and lower storage space for the same reliability than the ”hybrid strategy”. However, they have higher maintenance bandwidth.

4 Video streaming

4.1 Interactive Free Viewpoint Video Streaming Using Prioritized Network Coding

In [7], the authors propose an optimization problem for live free viewpoint video streaming over distributed and bandwidth-limited networks. They study a scenario in which video sequences acquired from each camera are real-time encoded into separate streams. These streams are delivered to servers, which distribute the data over an overlay network. The virtual views are synthesized via Depth Image Based Rendering (DIBR).

To allow each user to experience the Quality-of-Experience(QOE) level that better fits its requests and channel constraints, they propose a transmission scheme which combines layered camera sets with an unequal error protection (UEP) delivery schemes. Therefore they extend the concept of prioritized NC to the free viewpoint video streaming scenario.

The authors organize the seven physical cameras of the simulation setup in three disjoint subsets. They group the subsets in three classes. For each class one simulation is run in which only packets that belong to the corresponding class are communicated to the network. Additionally a simulation with UEP-NC is executed and compared to the results of the simulations for the classes.

Three results show that compared to baseline algorithms, the proposed UEP-NC scheme is able to achieve the largest QOE across different bandwidth availability, and different packet erasure probabilities. This result in the UEP-NC scheme offering the highest satisfaction of users in the interactive scenario.

4.2 Femtocaching and device-to-device collaboration: a new architecture for wireless video distribution

The work in [8] is motivated by the fact that video transmission is currently the main reason for the increase of both wired and wireless data traffic and propose an approach to improve the video throughput without deployment of any additional infrastructure. This approach is based on distributed caching of the content in femto-basestations with small or non-existing backhaul capacity but with considerable storage space, called helper nodes.

The approach is based on two key observations. On the one hand, a large amount of video traffic is caused by a few popular files, and on the other hand, disk storage is a quantity that increases faster than any other component in communications/ processing systems. The essential idea of the approach is to trade off backhaul capacity with caching of video files at local base stations or helper nodes from where they can be transmitted very efficiently.

The helper nodes operate in conjunction with a traditional, macrocellular base station. They cache data, that has already been requested from the base station. If a user requests a file that is cached in local helpers, the helpers handle the request; the macro base station manages the requests that cannot be handled locally.

Further the authors introduce the idea of using mobile devices such as smartphones, tablets and laptops as wireless helper stations. With this approach many video requests can be satisfied by D2D communications, without requiring any new infrastructure. A further advantage lies in the fact that helper nodes are automatically concentrated in the regions where there are also the requesting devices.

The simulations and analytical results show the concept to be an extremely promising way to alleviate the capacity bottlenecks for wireless video transmission. In simulations under realistic assumptions, the number of users that can be served is increased by as much as 400–500 %.

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