KING'S College LONDON
University of London

Enhance the Experience of Users over the Mobile/Wireless Internet

Toktam Mahmoodi
Centre for Telecommunications Research
King's College London
University of London

Toktam.Mahmoodi@kcl.ac.uk

University of Cambridge
11 November 2009

KING'S College LONDON
University of London

Outline

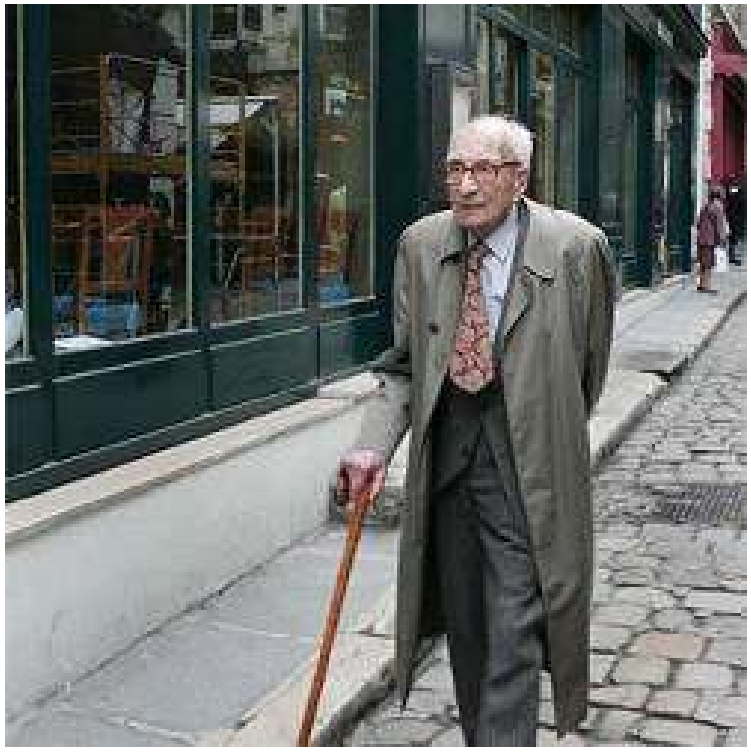
CENTER for TELECOMMUNICATIONS RESEARCH

- Wireless and Mobile communications.
  - Were we currently stand?
  - Mobile Internet Traffic forecast.
  - Constraints and new requirements.
- Design of a smart wireless link-layer.
- Some open-ended research problems
  - Look a head strategies.
  - Centralisation | Decentralisation.

KING'S College LONDON
University of London

To the "father of modern anthropology"

CENTER for TELECOMMUNICATIONS RESEARCH



Claude Levi-Strauss
28 Nov. 1908–30 Oct. 2009

- Claude Levi-Strauss is one of the central figures in the structuralist school of thought.
  - Structuralism has been defined as "*the search for the underlying patterns of thought in all forms of human activity.*"

KING'S College LONDON
University of London

Where we Currently Stand?

CENTER for TELECOMMUNICATIONS RESEARCH

Increasing the data rate by moving from 56kbps Dial-up connections to ADSL connections

Fiber optic cable enables high-speed networking

Wireless Networking faces the similar expectations

KING'S College LONDON
University of London

Mobile/Wireless Traffic Growth over the Internet

CTR CENTER for TELECOMMUNICATIONS RESEARCH

- The Internet is not an isolated phenomenon, but rather part of the general ICT revolution. Hence, many believes that its growth follows Moor's Law for semiconductors.
  - Gordon Moore had predicted that the number of transistors on a chip will double about every two years, which is popularly known as Moor's law.
- The Mobile Internet Forecast released in Jan. 2009 show.
  - The data growth of 400% between 2008-2013.
  - Video is responsible for the majority of this growth (?).

KING'S College LONDON
University of London

What are the existing constraints?

CENTER for TELECOMMUNICATIONS RESEARCH

- The wired network relies on the functionality of the transport protocol for the data transmission, among which the most popular is called TCP.
  - Currently TCP is responsible for the delivery of more than 90% of Internet traffic.
- TCP provides robust end-to-end communications,
  - Controls congestion over the end-to-end paths.
  - Provides reliability for the per flow data transmission.
  - Guarantee fairness among the competing flows of different characteristics (e.g. flows that face various round trip time or packet loss rate) .

KING'S College LONDON
University of London

TCP over Wireless

CENTER for TELECOMMUNICATIONS RESEARCH

- Despite the mentioned functionalities, TCP does not perform well over wireless networks due the wireless characteristics.
  - Random and burst packet loss.
  - Intermittent connectivity due to hand-off or loosing coverage temporarily.
  - The available resources are more scarce and pricy.
  - Wireless link-level algorithms allocate the resources according to the constraints and requirements of the wireless link, and are not interacting with the end-host TCP.
- TCP treats the random loss, intermittent connectivity, and scarce available bandwidth as congestion; thus reduce the data transmission rate.

KING'S College LONDON
University of London

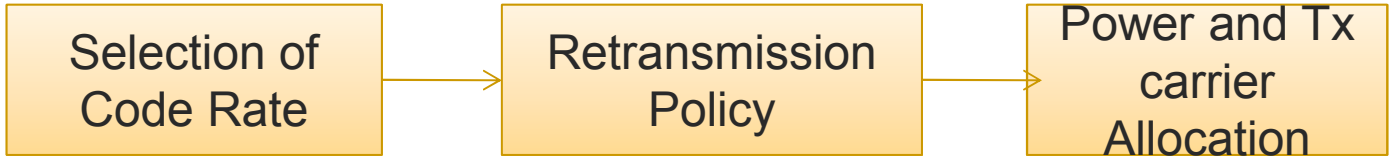
TCP over Wireless: solutions

CENTER for TELECOMMUNICATIONS RESEARCH

- To solve the misinterpretation of different types of packet loss with congestion, plethora of TCP variants are proposed, aiming to:
  - distinguish the source of loss.
  - Take more conservative approach towards congestion
  - change the notion of congestion
- On the other hand, the wireless link-layer can act so as to hide these issues from the end-host TCP.
  - Reliable link-layer is incorporated in almost all the current wireless technologies that attempts to provide reliability over the last transmission link.
  - The wireless scheduler can also consider the constraints of the end-to-end communications.

Smart Link-Layer Design

- TCP state variables (cwnd, and RTT), as well as the version (flavour) of TCP are used in the design of the wireless link-layer.
- A set of techniques are applied to the link-layer algorithms in the top-down fashion of the transmission pipe line.



KING'S College LONDON
University of London

FEC Rate selection

CENTER for TELECOMMUNICATIONS RESEARCH

- Upon transmission, link-layer codes data using various schemes i.e. reed solomon, and convultional coding; this allows the receiver to correct a proportion of errors caused by corruption from the wireless channel.
- The tradeoff here is between increasing the amount of trannsmission data and the amount of error that can be corrected.
- Knowing the version of TCP used at the end-host, the code rate is allocated so that vulnerable TCP flows are more protected.

KING'S College LONDON
University of London

Prioritising ARQ retransmission

CENTER for TELECOMMUNICATIONS RESEARCH

- Retransmissions of the lost packets at the link-layer is handled via ARQ mechanism that is mainly characterised by its level of persistency in the retransmissions.
  - The standard ARQ algorithm operates over a single FCFS queue.
- The prposed technique store packets in the priority queues after assigning a weight parameter to each packet. The weighing coefficinet is computed based on the RTT of the TCP flow.
  - This scheme can avoid up to 50% of the timer expirties at the TCP.

KING'S College LONDON
University of London

Power and Carreir Allocation

CENTER for TELECOMMUNICATIONS RESEARCH

- Various resource allocation startegy are in use over the wireless link as the last stage before the packte transmission; popular oschems are e.g. Round robinand maxC.
- The TCP-aware technique compute the theoretical TCP throughput that can be achieved over the end-to-end path (this is a function of the corresponding flow's RTT and PER).
  - This throughput is used as the optimal achievable throughput by that flow, thus the resource allocation scheme attempts to achieve as close as possible to that over the wieless link.

KING'S College LONDON
University of London

Opportunistic | Fair?

CENTER for TELECOMMUNICATIONS RESEARCH

- The allocation schemes at the wireless base station are mostly opportunistic; they attemp to maximise the wireless capacity.
  - Some allocation schemes consider also fairness over the wireless link, but aspects as pertain to the end-user can not be addressed.
- The discussed techniques in the TCP-aware link-layer not only can enhance the end-to-end throughput but also provide an opportunity for the fair allocation of resources among the end-to-end flows.

Opportunistic | Fair?

- The open discussion exist in the community to balance well between the opportunistic allocations and fairness.
- Also fairness can have various elaborations.
  - Max-min fairness
  - Proportioan fairness
  - Or any other quantitaive/qualitative index that is introduces by social science.

Browsing Webpage:
Faster for some | Available for all

- The web page response times can vary considerably based on the transport layer used as well as the location of end-host.
- By penalising the users with better experience, we can increase the number of satisfied (?!) users.
  - Some studies show that the average delay of 3s in loading a wqeb page can be tolerated by most of the Interent users.

Open-Ended Research Problems

- Look-ahead strategies:
  - The possibility exists to plan ahead; e.g. with looking into the requirements of a flow pror to connection setup, the end-server and end-to-end path can be selcetd accordingly.
- The vision of always on connectivity faces constraints such as power consumption.
- The availability of small wireless devices such as sensors everywhere and the various services that they utilise, dramatically adds to the heterogeneity of the wireless networks.

Look-ahead Strategies

- To provide such a predictive solution, a central management is required by the network.
  - To receive all the call requests.
  - To select the optimal end-server, and find the optimal rout with the considerations of the requested service, the wireless conditions, etc.
- Status of the current communicatiosn network?
  - Does centralise approach work?

Centralising | Decentralising
Telecommunications/Society

- First, the telephon centers were distributed.
  - One should call to their local center to connect to anywehre esle.
  - This is similar to classic socities with local goverments.
- Then, the telephony network became centralised.
  - Centralised switches handled the calls globally.
  - The transition was similar to how central government s were shaped.
- Modern communication network is distributed.
  - Large amount of processing was the main concern to decentralise the network.
  - Large societies distribute power within the local authorities.

Central Management is back on the table.

- Currently, with the increasing number of services and applications i.e. multimedia, the centralise idea returned by the all IP networks.
- The centralised design can be beneficial also for the power consumption.
- The proposals such as cloud computing are in support of the central management.
  - The main computing will be handled by the IP cloud .

KING'S College LONDON
University of London

Conclusions

CENTER for TELECOMMUNICATIONS RESEARCH

- The dream of always on connectivity came true; although we face new constraints in the service of such a large and heterogenious wireless network.
- The problems that address these constraints are yet open ended.
  - Some solutions are presented in this talk.

KING'S College LONDON

University of London

Thanks for your attention!

Toktam.Mahmoodi@kcl.ac.uk

University of Cambridge
11 November 2009