ONBOARD PROXY TECHNIQUE IN 4G GENERATION

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Abstract- The scenario involved in the 4G mobile communication development is considered in this paper. The next generation in mobile communication will not rely on a new radio infrastructure; instead, its peculiarity will be the ability to take the best from every connection technology switching among them depending on the best options available to the user. In an emergency situation when power goes out, satellites combined with the use of sky objects flying above the crisis area, could represent the only communication way left to the terrestrial infrastructure. This paper shows the benefits attained by the TCP Westwood (an enhanced end-to-end version of TCP able to deal more effectively on connections having a wireless segment between source and destination) protocol coupled with a proxy employment on a satellite link utilized to restore connectivity in an urban crisis scenario. This new transport protocol utilizes a sender-side Eligible Rate Estimation to discriminate between congestion and wireless errors.

Keywords: **TCP Westwood; Proxy; Congestion.**

I. INTRODUCTION

We are leaving in a Communication Era where computers and connectivity are becoming increasingly personal and essential. In this scenario, imagine also an emergency situation when power goes out and all the Hot Spots and Cellular Base Stations shut off thus impeding any kind of communications. Similar crisis conditions in an urban area could occur when there is a chemical or nuclear disaster caused by human error, plant break down, act of war or terrorist attack. Yet, this is the time when communications are indispensable to control all the emergency operations and a rapid deployable connectivity must be guaranteed. In these circumstances, satellites combined with the use of sky objects flying above the crisis area, could represent the only communication way left to the terrestrial infrastructure**.** The above depicted situation leads us toward an Always-On future. Not only, are people going to demand the technology required to be Always Best Connected. This new philosophy will permit users to exploit the locally best offered access for their needs. In each moment and ubiquitously, a person will be able to choose between the various connections available (wired access, Bluetooth, WLAN, 2.5G, 3G, etc.) or a combination of them, and between the various devices available depending on the application requirements e.g., screen size, energy consumption, mobility, processing capabilities, network interfaces, etc.Therefore, the 3G following generation of communication, namely **4G**, will not necessarily rely on an independent new radio infrastructure, instead its peculiarity will be the integration of heterogeneous segments exploiting different technologies within the common glue of the Internet.

II. PROBLEM STATEMENT

Always Best Connected scenario involves several levels of complexity that spread both on technological solutions for terminals and networks, and on business agreements between access operators, service providers and final users.

A. Complication Factors

The considered environment, in fact, is complicated by several factors:

- Users mobility with consequent roaming, fading, disconnections, and latency variability
- Heterogeneous devices with different features and constraints
- Multiple wireless access technologies
- Users interaction and preferences in independently choosing access scheme
- Time varying traffic pattern (by load, type and priorities)
- System prone to high interference and congestion (elevate packet loss ratio and highly variable load)

B. Main Designing Challenges

If we include in the depicted scenario also the need for an Always-On connectivity, even in case of urban disaster, the main designing challenges that we have to face can be summarized as follows:

1) Flying Objects and Satellites

In an urban crisis scenario, where some disaster has brought power and telecommunication systems to a standstill, it is very cost effective to deploy in a short time a system composed of several HAPS (High Altitude Platforms Stations) or UAVs (Unmanned Airborne Vehicles) to establish an emergency telecommunication infrastructure. The HAPS/UAV may fly through the "urban canyons" acting as repeaters. The mobile users on the ground can use HAPS/UAVs to communicate with each other and to access a remote ground station or the Internet via Satellite as depicted in Fig.1. This two level "satellite empowered" architecture combines the advantage of having a very small user terminal technology on the mobiles with the capability to establish very long range connections. Thus, the access protocol will be 802.11, compatible with existing Hot Spot environments.

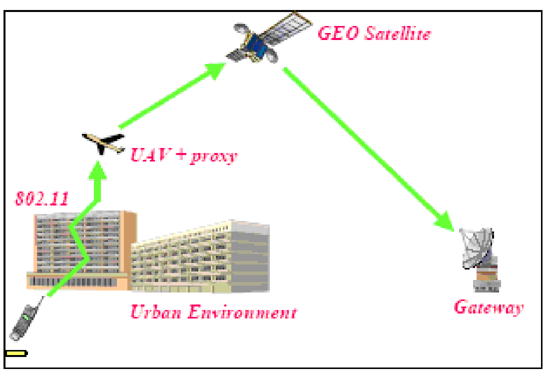


Fig. 1. HAPS/UAV and satellite communication scenario

2) Wired-Cum-Wireless Protocols

TCP/IP suit of protocols was designed in a time when networks were based exclusively on wired technology, its mechanism fails when plunged into a wireless environment. TCP uses packet losses as a metric to evaluate the congestion level of the network, thus shrinking the sending window. The 802.11 MAC layer protocol attempts to face the packet loss problem by implementing its own retransmission scheme. This scheme hides wireless error losses from the TCP's congestion control mechanism, thus avoiding deleterious multiple reductions of the data sending window. On the other hand, local retransmissions affect packet delivery delay.

3) *Horizontal/Vertical Handoff*

In a mobile scenario, horizontal handoff occurs regularly, every time the user crosses two cells of coverage for the technology in use. Moreover, as depicted in Fig.2, the notion of handoff as the last resort to maintain the connectivity needs to be enhanced with the concept of vertical handoffs. The transition should be smooth to avoid performance degradation.

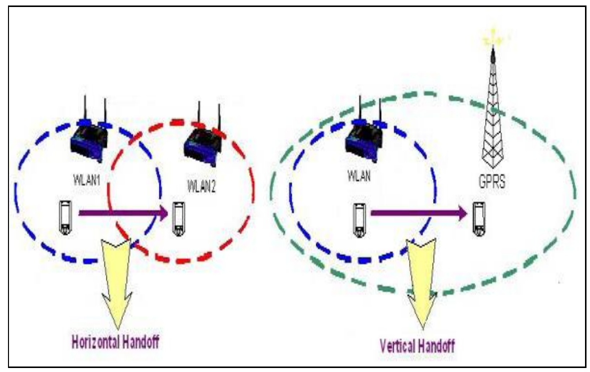


Fig. 2. Horizontal/Vertical Handoff

4) Rate/Content Adaptation

The deployment of agents, proxies and "smart" clients could help in taking intelligent decisions and sharing responsibilities regarding caching and pre-fetching, data delivery ratio, compression level utilized, etc. This combination of efforts has to rely on scalable adaptation techniques and encoded content suited for on-the-fly adaptation.

5) QoS Maintenance

In a scenario where users dynamically change the best access to multimedia services, the presence of Quality of Service (QoS) support is crucial. The next-generation wireless multimedia communication systems, in fact, requires efficient mechanisms for QoS provision able to operate even over unreliable, unstable and mostly unpredictable channels.

6) Mobility

The Always Best Connected philosophy passes through the utilization of different devices characterized by their own features and, among these, the user can chose the one that best suit his/her needs. If the running application is a stream of some kind of data, then the only need is that we have to move to some connectivity information; otherwise, in case of downloading, the amount of data to be transferred could be greater unless having previously stored part or all of it in both the devices.

7) Wireless Security

A ubiquitous use of mobile terminals across a variety of wired and wireless connections requires effective security architecture. Even with various advancements in many issues related to wireless technology, security requirements are still difficult to guarantee. The open nature of mobile access, with communication signals that spread from the source in every direction around it, represents a very tough obstacle to security. Despite of this, in order to really reach customer's needs, wireless technology has to be enhanced to authenticate and authorize users utilizing system resources.

8) Access Discovery/Selection Mechanisms

The mobile terminal has to be enhanced with an access discovery function that periodically looks for better alternatives. In order to classify the diverse access options and being able to efficiently choose between them, we need to find the best tradeoff between several issues. First of all, devices have to be able to discriminate between access network technologies, operators, pricing, QoS required and user's preferences through a set of general parameters. Then, we have to define a set of metrics on the various access types that can be used as statistics to determine the best choice for future accesses. The selection process is made of choices that are based on the terminal used, the networks available and user's predilections. The latter part requires the presence of an easy-to-use tool that shows the various options in a way that supports customers in taking decision that are beneficial for his/her needs. Finally, in both cases of first access and loss of currently used connectivity, the terminal must be able to discover and select another access option without any support from the network.

9) Wireless Grid and Peer-To-Peer Extensions

Wireless communications, Peer-to-Peer (P2P) and GRID networking probably constitutes the three highest scale technology trends of the past few years. Grid and P2P have much in common: both are concerned with the coordinated use of resources within distributed communities and operates as overlay networking structures. Information gathering involving physical proximity to a specific location could receive more efficient service utilizing direct connections instead of a centralized architecture. At the same time, GRID technology has emerged as the ideal tool to create scalable virtual organization of computers. Its capability would be especially useful if we imagine a scenario requiring more powerful resources than those available in a mobile terminal, as it could be an urban traffic grid.

III. CURRENT APPROACH

The realization of a factual Always Best connected world cannot rely on a single technology. Indeed, various integrated approaches should be taken in mind. The common glue between the two proposed solutions is the presence of TCP Westwood: an enhanced end-to-end version of TCP able to deal more effectively on connections having a wireless segment between source and destination. This new transport protocol utilizes a sender-side Eligible Rate Estimation to discriminate between congestion and wireless errors. This paper shows the benefits attained by this protocol coupled with a proxy employment on a satellite link utilized to restore connectivity in an urban crisis scenario. Moreover, a capacity estimator is suggested: indeed, a possible employment of this tool could be in helping TCP Westwood to avoid bad samples while computing the shared bandwidth.

A. On-Board Proxy Technique

In certain undeveloped environments or emergency urban situations, satellites may **r**epresent the only communication way left. Moreover, we can introduce an innovative architecture involving the exploitation of unmanned flying objects (HAPS/UAV) or stationary sky station at relatively low altitudes to reduce the shadowing impairment. Splitting the connection into two parts and creating a short range link with the user terminal directly faces the very high loss ratio present especially in the first part of the connection. The two systems can be coupled having the latter the role of collecting information from user terminals and fast recovering from error losses.

Different ways of maintaining TCP connections:

- Wired-cum-wireless designed transport protocol: TCP Westwood.
- Splitting the TCP connection boarding a proxy server on the HAPS/UAV. Dividing the problem into two sub problems.
- Combination of a new transport protocol and the splitting scheme**.**

- The scheme here proposed utilizes a division of the path into uplink and downlink and requires the presence of a cache to store packets received and not still transmitted.

Splitting the connection violates the end-to-end paradigm, but this problem could be alleviated in two ways.

- Acknowledgments are sent back from the HAPS/UAV to the source when the packet is successfully transmitted on the channel down to the mobile and not as soon as it receives the packet.
- The signals of correctly closed connection do not follow the splitting mechanism**:** the signal should be received from the mobile device and then forwarded.

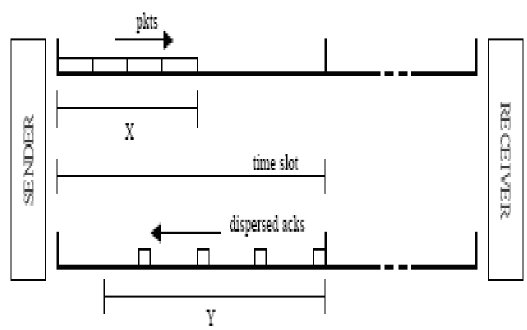
B. Residual Capacity Estimator

A packet train is a set of packets which depart from the sender grouped together with no idle time between transmissions. Traveling along the path, these packets could be delayed in different ways such that the destination will observe a different distribution than the starting one. Packets, in fact, could be dispersed by narrow links or could be delayed in queue for different times if concurrent traffic is present on that link. Acknowledgments leave the destination at a time that depends on the correspondent packets receiving time and their dispersion once reached the sender could be used in order to infer information as the capacity or the bandwidth of the bottleneck.

In a normal TCP connection, packets does not leave the source one close to the other in a train configuration, instead, their departure time is beaten by the returning acknowledgment time. Therefore, it is not possible to use a packet train technique with TCP, unless we modify it. At the same time, sending real packet trains on the channel could suddenly increase the congestion level thus causing multiple losses and consequent performance degradation. For all these reasons, we **p**ropose a scheme named Residual Capacity Estimator (RCE) that is perfectly embedded in the normal TCP behavior and, at the same time, recall the packet train technique. RCE is a very simple and cost effective mechanism able to calculate the bottleneck capacity. RCE can have several applications as, for instance, discarding overestimating samples in bandwidth estimation technique, determining the appropriate routes/tree for multicast overlay networks, calculating the most appropriate rate in video/audio streaming.

In Fig. 3 time is divided into slots and a single TCP sends a packet train toward the receiver. We indicate with X the part of the slot used to transmit the packets back to back and with Y the time needed to contain the dispersion of the correspondent acknowledgement. Considering the time slot equal to 1, the maximum portion of the slot usable to send packets corresponds to Y/X.

Fig. 3. Acknowledgement dispersion due to bottle neck link



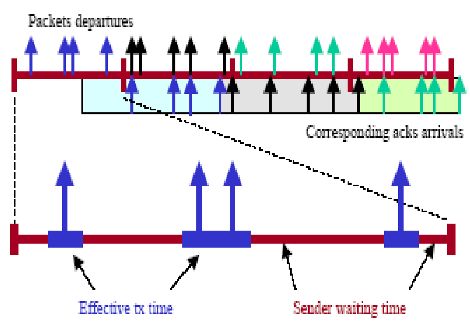


Fig. 4. Packets-slots and acknowledgments-slots division

The acknowledgements distribution is characterized by gaps that depend on various factors:

- Different capacity between outgoing link and bottleneck link.
- Queuing time caused by congestion.
- Different size, and thus channel occupancy, between data packets and acknowledgment.
- Wasted time due to a low sending window.

RCE scheme divides time both into packets-slots and acknowledgment-slots. When the correspondent returning acknowledgments come back we determine the size of the acknowledgment-slot as shown in Fig. 4: the slot starts with the end of the preceding one and ends with the receiving of the acknowledgment for the last packet sent in the correspondent packets slot. Since the number of packets-slots and of acknowledgment -slots is the same, on average they will have the same length. When the acknowledgment corresponding to the sent packets come back, RCE computes the bottleneck capacity as

$$\frac{Bits\_acked\_in\_slot}{Acks\_slot\_time - Wasted\_time}.$$

Our scheme measures the average of the inter arrival time between the acknowledgments of the current acknowledgment-slot. The Wasted time is then computed as the sum of the time exceeding this average in each inter arrival time included in the acknowledgment-slot. The rationale of this formula is the fact that all the packets will experience the same channel conditions in terms of transmission time, but not all of them will endure the wasted time due to a low sending window. Therefore the average exceeding gap times between acknowledgments is most likely a result of having periods of no transmissions due to the sending window size than for channel characteristics.

Focusing on queuing time, we have to notice that, since the bulk nature of TCP transmission, this element will not be endured evenly by all packets in a slot. Consequently, unless the link is experiencing heavy congestion, queuing time is removed by our mechanism in case of contemporary presence of other TCP flows and the final result is the capacity of the bottleneck. RCE returns the bottleneck capacity, detracted the portion of channel occupied by the uniformly distributed traffic. Moreover, this is obtained since the very beginning of the connection and no special packets or TCP modified behavior is required.

1) Pseudo-Code Of RCE

The pseudo-code of RCE given below shows that the scalability of RCE is assured by the very easy set of calculations and by the very few information we need to store at sender side about the TCP flow. Moreover, the proposed mechanism is perfectly embedded into the standard TCP operations.

Implementation of Pseudo-code

- At sender side, time is divided into slots
- In each slot, N packets are sent to destination
- The corresponding N acknowledgment will return back in ack_slot_time
- Sender_waiting_time is calculated as:

```
 Sender_waiting_time = 0;
 Calculate AVG_acks_interarrival_time;
 For each acks_interarrival_time of the slot
{
     If acks_interarrival_time >
AVG_acks_interarrival_time
       {
          Diff = acks_interarrival_time –
AVG_acks_interarrival_time;
          Sender_waiting_time = Sender_waiting_time
+ Diff;
        };
   };
```

- The sample is: Cap_sample=Bits_acked/ (Acks_slot_time– Sender_waiting_time)
- This is averaged as:
  Cap_est = 0.5 * Cap_sample + 0.5 * Cap_est

IV. CONCLUSION

This paper has mainly been focused on the transport layer performance. We have presented a proxy-involving architecture for providing connectivity after an urban disaster and a new capacity estimator (RCE). In the former, the combined use of HAPS/UAVs and satellites is identified as the most efficient architecture to rapidly restore service on long range connections distributed traffic. RCE scheme is perfectly embedded in the TCP normal functioning. RCE returns the bottleneck capacity, detracted the portion of channel occupied by the uniformly distributed traffic. Moreover, this is obtained since the very beginning of the connection and no special packets or TCP modified behavior is required. The integration and interoperability of the 4G targeted solutions that is going to develop, along with truly user-oriented intelligent services, will lead us to the ubiquitous Always Best Connected world that will forever enhance every aspect of our everyday life.

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