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FACULTY OF COMPUTER SCIENCE AND AUTOMATION

COMPUTER SCIENCE MEETS AUTOMATION

VOLUME II

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Session 10 - Mobile Communications

Session 11 - Education in Computer Science and Automation

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Preface

Dear Participants,

Confronted with the ever-increasing complexity of technical processes and the growing demands on their efficiency, security and flexibility, the scientific world needs to establish new methods of engineering design and new methods of systems operation. The factors likely to affect the design of the smart systems of the future will doubtless include the following:

- As computational costs decrease, it will be possible to apply more complex algorithms, even in real time. These algorithms will take into account system nonlinearities or provide online optimisation of the system's performance.
- New fields of application will be addressed. Interest is now being expressed, beyond that in "classical" technical systems and processes, in environmental systems or medical and bioengineering applications.
- The boundaries between software and hardware design are being eroded. New design methods will include co-design of software and hardware and even of sensor and actuator components.
- Automation will not only replace human operators but will assist, support and supervise humans so that their work is safe and even more effective.
- Networked systems or swarms will be crucial, requiring improvement of the communication within them and study of how their behaviour can be made globally consistent.
- The issues of security and safety, not only during the operation of systems but also in the course of their design, will continue to increase in importance.

The title "Computer Science meets Automation", borne by the 52nd International Scientific Colloquium (IWK) at the Technische Universität Ilmenau, Germany, expresses the desire of scientists and engineers to rise to these challenges, cooperating closely on innovative methods in the two disciplines of computer science and automation.

The IWK has a long tradition going back as far as 1953. In the years before 1989, a major function of the colloquium was to bring together scientists from both sides of the Iron Curtain. Naturally, bonds were also deepened between the countries from the East. Today, the objective of the colloquium is still to bring researchers together. They come from the eastern and western member states of the European Union, and, indeed, from all over the world. All who wish to share their ideas on the points where "Computer Science meets Automation" are addressed by this colloquium at the Technische Universität Ilmenau.

All the University's Faculties have joined forces to ensure that nothing is left out. Control engineering, information science, cybernetics, communication technology and systems engineering – for all of these and their applications (ranging from biological systems to heavy engineering), the issues are being covered.

Together with all the organizers I should like to thank you for your contributions to the conference, ensuring, as they do, a most interesting colloquium programme of an interdisciplinary nature.
I am looking forward to an inspiring colloquium. It promises to be a fine platform for you to present your research, to address new concepts and to meet colleagues in Ilmenau.

Professor Peter Scharff
Rector, TU Ilmenau

Professor Christoph Ament
Head of Organisation

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52nd Internationales Wissenschaftliches Kolloquium
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Ngo Ai Tam

RCS-M: A Rate Control Scheme to Transport Multimedia Traffic over Satellite Links

INTRODUCTION

Satellite communication systems [7,8] are being developed very quickly in many countries around the world, promising new capability for wideband Internet and new broadcasting services. Satellite communication systems become a new media in addition to traditional communication systems based on copper cable, optical cable, marine cable and microwaves. Due to the operation at rather high altitudes, satellite communication can cover a rather wide territorial region and surmount the distance limitation of the current fixed and wireless links.

However, due to the signal transmission through the space, satellite communication has to face technical challenges such as high bit error rates, limited bandwidth, interference, etc. The signal transmission over the space can be degraded and disturbed by environment and weather condition, etc. On the other hand, the demand on multimedia services grows very fast. Multimedia services have stringent requirement on quality service. In order to ensure quality service over satellite links, suitable control mechanisms are needed. Recently, new technologies and techniques have been developed including the modification of traditional techniques used in fixed networks, new designs with respect to particular properties of satellite links. In fact, investigation and development of control mechanisms for Quality of Services (QoS) over satellite links remain a technical challenge. Suitable control mechanisms need to consider properties of satellite environment and should ensure QoS as well as be able to congestion control. Current research works [2,3,5] showed that neither traditional TCP and UDP protocols are suitable to transport multimedia traffic over satellite links. The delay and error bit of satellite links have considerable influence on the operation of TCP. Modifications are needed such as: window size increase, slow-start, using congestion control, more effective acknowledgement mechanism, reduction of backward traffic, etc. However, TCP itself is affected by delay and bit error on satellite links and is inappropriate to transport multimedia traffic because of its retransmission mechanism due to packet loss. UDP is also inappropriate because there is no guarantee about the order of packets. Thus, there is a need to develop new transmission protocols which can overcome these difficulties and support multimedia transmission over satellite channel. In recent years, novel protocols, such as RAP (Rate Adaptation Protocol) [10] and RCS (Rate Control Scheme) [2,5] have been proposed to improve data transmission in environment of high bit error rates and high bandwidth-delay product. However, both RAP and RCS still

persist with blemishes. In this paper, we propose a Rate Control Scheme to transport Multimedia traffic over satellite links named RCS-M, which combines the advantages of both RCS and RAP (where M stands for Multimedia).
The paper is organized as follow. In section 2, we introduce RCS-M and present some simulation results in section 3 to show that RCS-M outperforms its predecessors. The experiments indicate that our protocol can be deployed for multimedia transport over satellite links with QoS guarantee in a TCP-friendly fashion. Finally, the section 4 concludes the paper.

RCS-M: A PROTOCOL FOR MULTIMEDIA TRANSPORT OVER SATELLITE LINKS

RCS-M Architecture

RCS-M is an end-to-end rate control scheme, which uses additive-increase, multiplicative decrease (AIMD) [13] to transmit multimedia and run on top of UDP. RCS-M uses dummy packet [5] to distinguish packet losses. The cause of packet loss may be network congestion, link error or temporary signal loss. The disconnection might also be due to handoff, signal fading regarding environment obstacles such as mountains, bridges, tunnels, or weather conditions such as storms, rains etc. Thus, the data could not be successfully transmitted to the receiver and hence performance severely degrades.

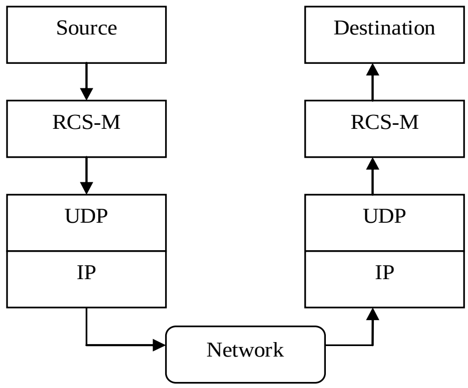

Fig 1. RCS-M Architecture

At the destination, the RCS-M layer sends back an acknowledgement (ACK) for any received packet. These ACKs are used only for flow control. The RCS-M receiver passes the received data packet to the decoder and discards dummy packets.

Components of RCS-M Architecture

The RCS-M architecture consists of following components:
+ Init: used to set up the connection between RCS-M source and RCS-M destination.
+ Timeout Timer: used to establish the system timeout.
+ RTT-Estimator: used to estimate the suitable Round Trip Time (RTT).
+ ACK Counter: used to count the number of received ACKs.
+ Initial Rate Calculator: calculates the suitable initial sending rate for RCS-M.
+ Rate Regulator: used for transmission rate control.
+ Dummy Packet Generator: generates and transmits dummy packets for checking network state (network resources).
+ Packet Sender / Receiver: for sending and receiving data packets.
+ Packet Loss Detector: used to distinguish the packet losses due to congestion, link error or temporary signal loss.
+ Backoff: this component used to adjust the rate in case of packet loss due to temporary signal loss.

As indicated above, RCS-M is based on the use of dummy packet. Dummy packets are low priority packets used by the source to probe the availability of network resources. When network is congested, dummy packets will be discarded first. Hence, the transmission of dummy packets does not decrease throughput of data packets. If network is not congested, dummy packets arrive at destination and ACK packets are sent back. These ACKs for dummy packets have low priority. As the source receives ACKs of dummy packets, it indicates that there are unused resources in the network and the source can increase its transmission rate accordingly. RCS-M transmits dummy packets in two cases: at the connection setup and when a data packet loss is detected.

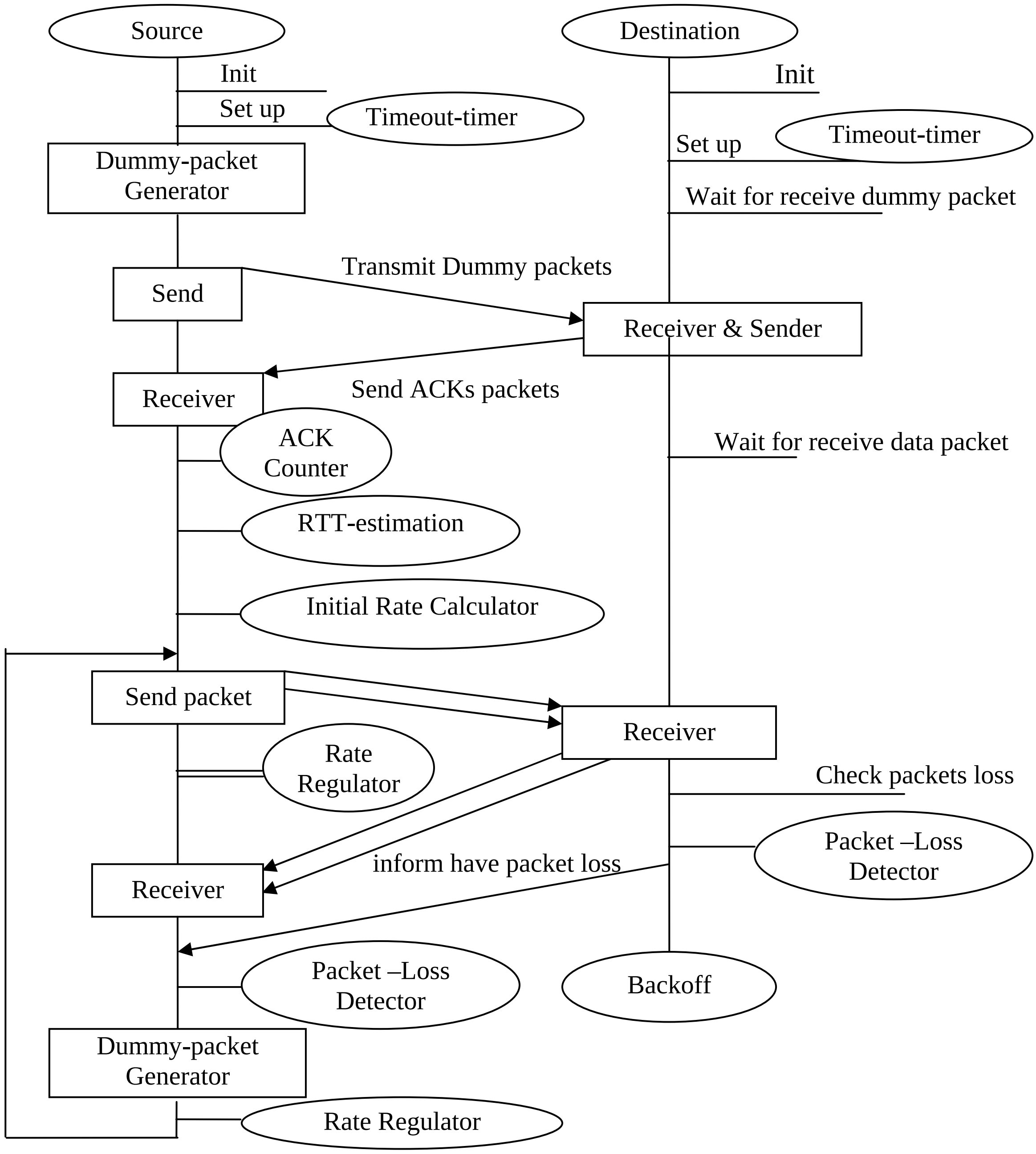

Fig 2. Principle of operation of RCS-M

Operation of RCS-M Protocol (Figure 2)

First, source and destination will be connected and set up the necessary timeout. The source sends dummy packets to the destination, and the destination sends back ACKs packets for the source counts. After that, it estimates RTT value and calculates the sending rate. Meanwhile the destination waits for receiving next packets.

When calculating RTT and transmission rate, the source transmits data packets. If detected packet loss, the source sends dummy packets and regulates suitable rate. RCS-M source waits dummy packets for determining the cause of packet loss. Then, RCS-M switches to suitable state.

State of RCS-M

RCS-M is implemented by a finite state machine model with four states: Initial, Steady, Detected and Backoff (Figure 3). In Initial state, the source sends dummy packets, which are used to probe the network resources, to decide the initial transmission rate that does not cause congestion. In the Steady state, RCS-M source assumes that the network is not congested. Thus, according to the additive-increase scheme [13], it increases its transmission rate in a step-like fashion periodically. When a data packet loss is detected, RCS-M source leaves the Steady state for the Detected state. At start of Detected state, RCS-M doesn't known the reason of packet loss, thus, it assumes that all packet losses are due to network congestion and halves its data transmission rate, simultaneously it also starts transmitting dummy packets in order to probe availability of network resources and distinguish the cause of lose packets. At the end of the Detected phase, RCS-M source goes back to the Steady or Backoff state. In the Detected phase, data packets are sent with rate S and two dummy packets are transmitted for each data packet. , RCS-M source waits for an ACK during the Detected state to assess the actual reason for the packet loss event. If the packet loss is due to the random link error, then RCS-M source receives an ACK during the SRTT period of Detected state. If the packet loss is due to congestion, then all TCP friendly protocol sources along the bottleneck would perform rate throttle for congestion resolution in at most one SRTT. Hence, if no ACK is received until the end of one SRTT, it can be inferred as an indication of temporary signal loss instead of the congestion. If no ACK is received during the Detected phase, then the RCS-M source does not go back to Steady state, instead it goes to Backoff state. In Backoff state RCS-M source sends one dummy packet for each data packet transmitted. During Backoff phase, RCS-M source stops halving its transmission rate and waits for an ACK informing that signal is back. Once RCS-M source receives any ACK for either data or dummy packet, it goes into Steady state. If no ACK is received for a certain timeout period, the source timeouts and moves back to Initial State.

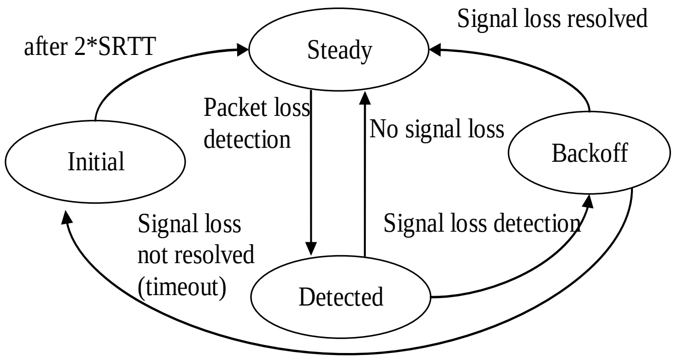

Fig 3. State of RCS-M

SIMULATION RESULTS

Simulation scenario

Satellite network is a typical example of network with high bandwidth-delay products and high bit error rates. The simulation system is shown in Figure 4 where N sources transmit data to N destinations. N sources and N destinations are connected with Earth Station A and Earth Station B that receives and transmits satellite signals. We assume that N=4, packets of length is 1000 bytes.

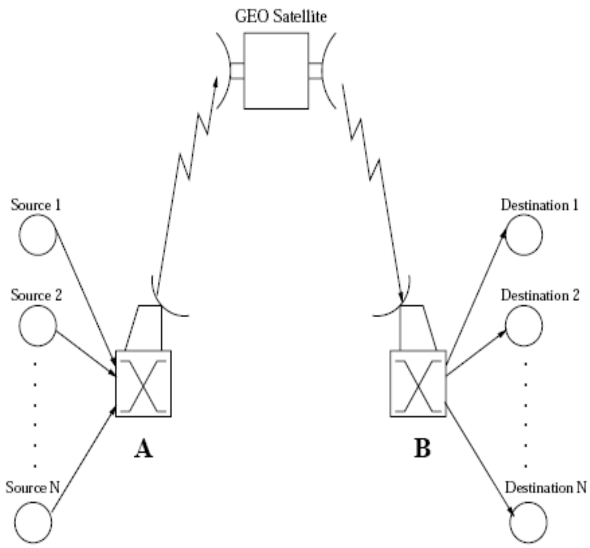

Fig 4. Simulation configuration

Simulation results

Figures 5a - 5f show the experiment results for sending rate (5a), throughput (5b, 5c,5d), fairness (5e, 5f) of RCS-M in comparison to the original RCS proposed in [5].

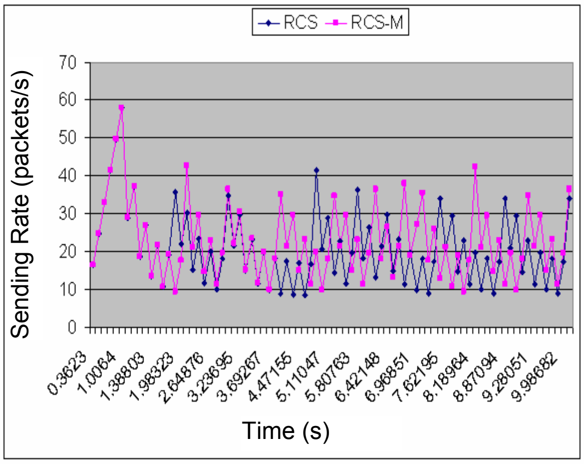

Fig 5a. Sending rate of RCS-M in comparison to RCS

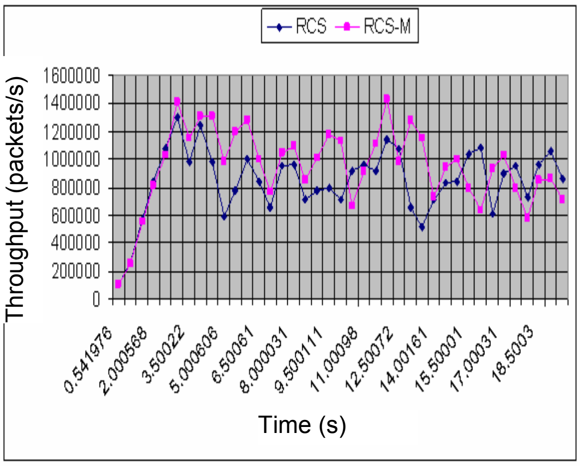

Fig 5b. Throughput of RCS and RCS-M with Initial rate = 22 packets/s

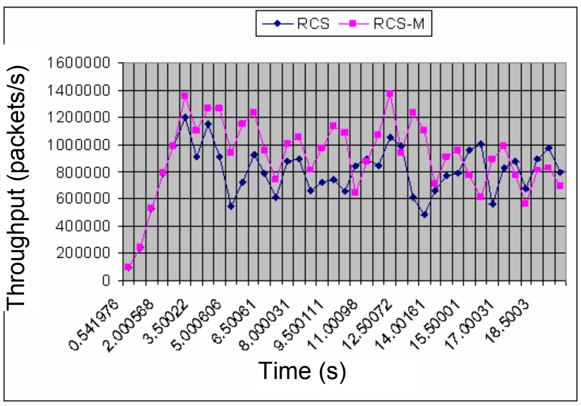

Fig 5c. Throughput of RCS and RCS-M with packet length = 1000 bytes

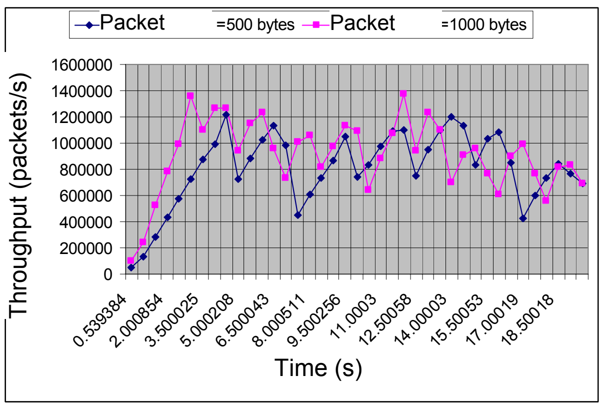

Fig 5d. Throughput of RCS-M with different packet sizes (500 bytes, 1000 bytes)

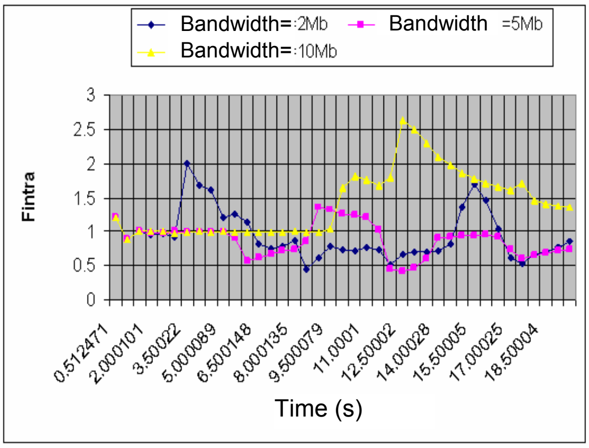

Fig 5e. Fairness of RCS-M flows (Intra fairness)

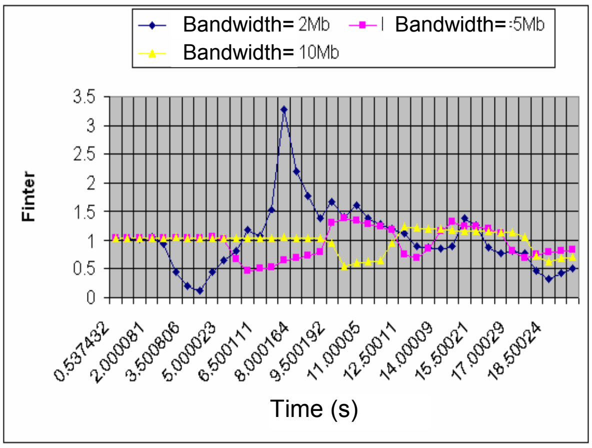

Fig 5f. Fairness of RCS and RCS-M (Inter fairness)

The experiment results showed the performance improvements of our RCS-M protocol with respect to the old RCS protocol proposed in [5] in the same simulation conditions.

CONCLUSION

Multimedia transmission over satellite links faces several technical challenges due to the properties of environments and QoS requirements of multimedia flows. In the paper, we have presented a new protocol based on an end-to-end control scheme called RCS-M using dummy packets and packet loss detection. RCS-M run directly on top of UDP and is TCP-friendly. The simulation results showed that our RCS-M is suitable for multimedia transmission over satellite links and can help to improve transmission throughput in comparison to the old RCS protocol.

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