# VTP: smooth, efficient and friendly video streaming in wireless networks

Guang Yang, Mario Gerla, M. Y. Sanadidi

Computer Science Department
University of California, Los Angeles

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# Background

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- Video is an important Internet application
  - Pre-stored video clips, e.g., video-on-demand
  - Real-time streams, e.g., live broadcast, online gaming
- Video streaming is a long time research interest
  - Many schemes proposed for adaptive congestion/rate control
  - Sender-based, e.g. Binomial algorithm (generalized AIMD)
  - Receiver-based, e.g. TEAR
  - Equation-based, e.g. TFRC
- Video streaming to wireless/mobile devices
  - Getting popular with prosperity of wireless technologies
  - Congestion/rate control for wireless video is different

# VTP: Designed for Wireless

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- Prior work on congestion/rate control of video streaming:
  - TCP-like: not suited for real-time/interactive apps:
    - Fluctuations in instantaneous rate
    - Large buffering at client is needed, incurring delays
  - TFRC: not robust to wireless loss
    - Efficiency drops in wireless networks

- VTP goal:

  *Develop a rate congestion/control mechanism to support smooth, efficient, friendly real-time video streaming in wireless networks.*

# VTP Features

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- VTP is a congestion/rate control protocol
  - Targeting real-time adaptive video streaming

- VTP provides:
  - Smoother congestion control (new)
  - Robustness to random loss (new)
  - Friendly co-existence with TCP and other traffic

- VTP features rely on two key components
  - Achieved Rate Estimation
  - Loss Discrimination techniques

- VTP can be integrated into DCCP as a congestion control option

# Achieved Rate Estimation

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- Achieved Rate (AR): rate that sender has pushed through the bottleneck link successfully.
- AR is measured at receiver by counting received bytes, plus (estimated) bytes lost due to errors.
- AR is good indication of the "appropriate" sending rate when packet loss is detected
  - Cleverer than "cutting by half"

# Loss Discrimination Algorithm

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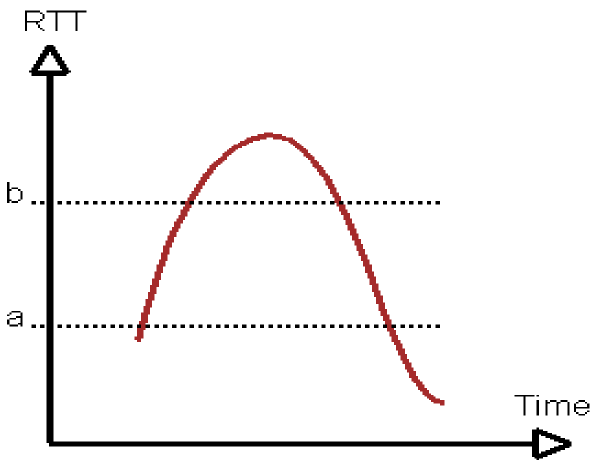
- Differentiate congestion and random packet loss
  - Only congestion loss triggers rate reduction
  - Robust to random loss
- Many e2e LDAs exist
  - We choose a variant of Spike
  - Idea: large RTT indicates imminent congestion
  - Spike is accurate in wireless LAN scenarios that VTP targets




Spike:

RTT > b: congestion
RTT < a: error
a<RTT<b: no change

# Mimicking TCP Sending Rate Dynamics

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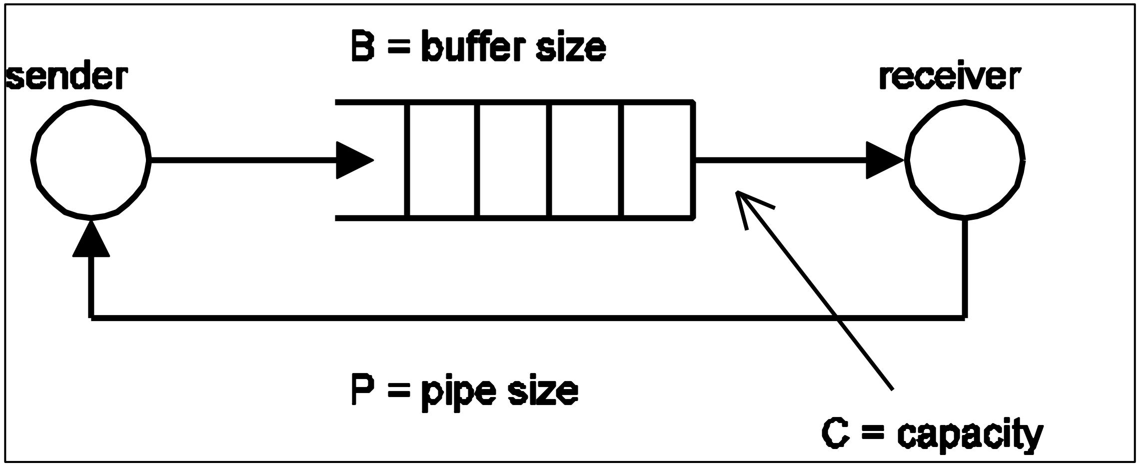
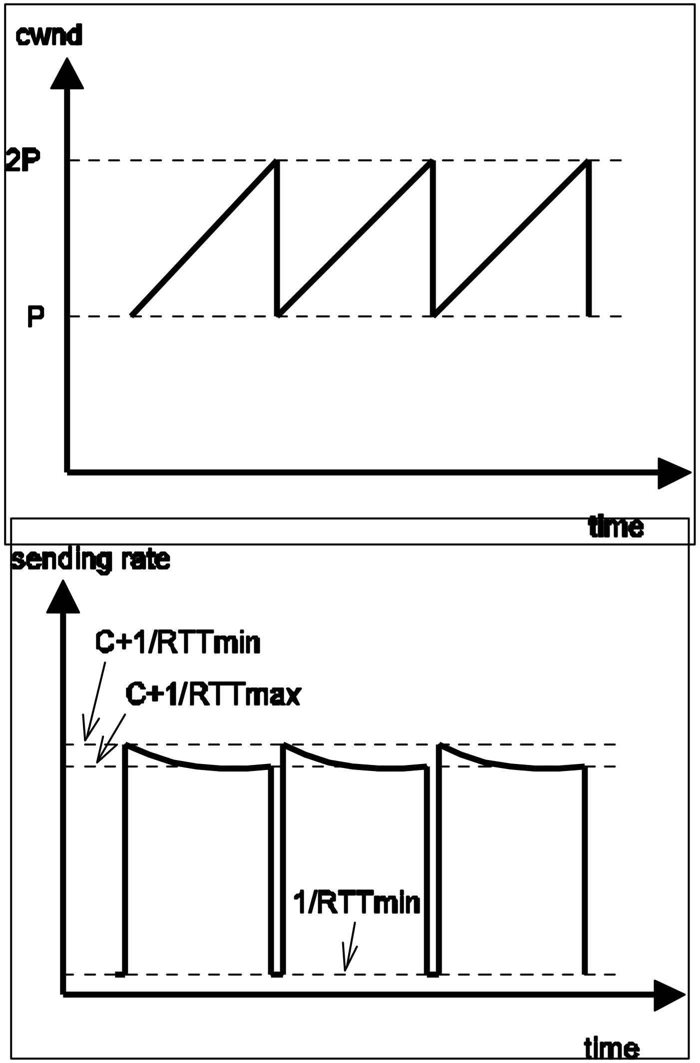



- Start from simple topology
  - Single hop, single flow
  - Assuming *buffer size = pipe size*
    - Pipe size: bandwidth-delay product

# TCP Instantaneous Sending Rate




- Top: *cwnd*
  Bottom: *sending rate*
  - RTTmin/RTTmax correspond to empty/full queue buffers
- Observation:
  - When cwnd is cut by half, *instantaneous sending rate* is cut to near-zero.
  - *Rate* bounces back up much faster than *cwnd*.

(See additional slides at the end for detailed illustration)

# VTP matches TCP effective Rate

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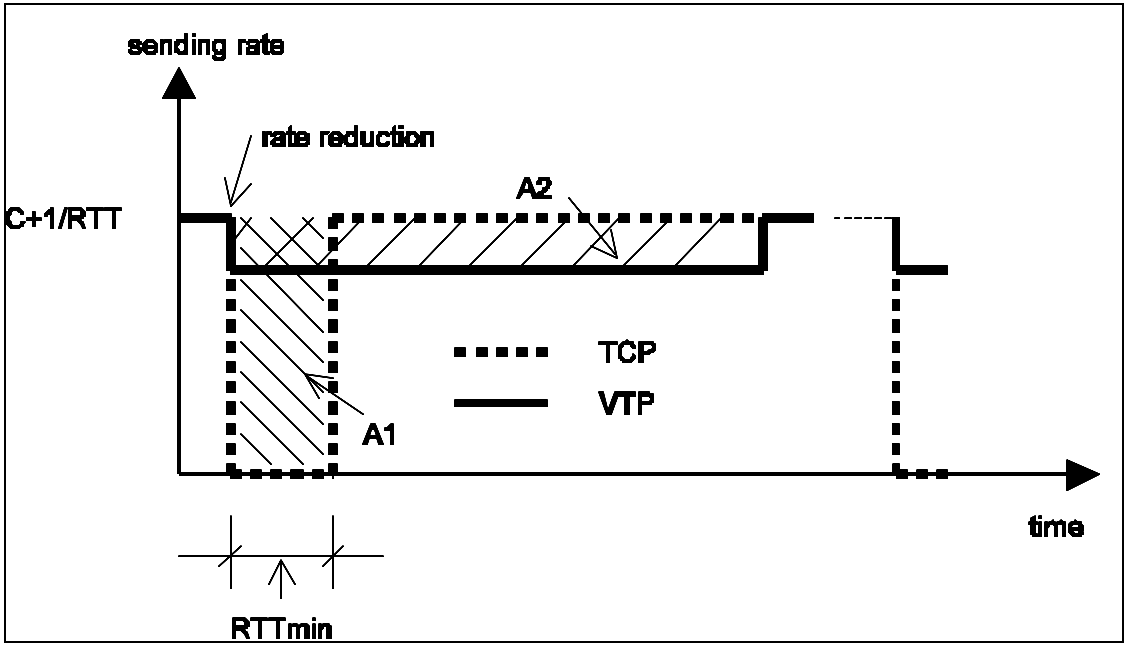


- Based on TCP behavior shown on previous slide
- When rate is reduced, VTP avoids "near-zero".
  - Less reduction stretched over longer period.
- Let A1 = A2, VTP and TCP give up the same amount of data upon a congestion packet loss.

# Ns2 Simulation Setup

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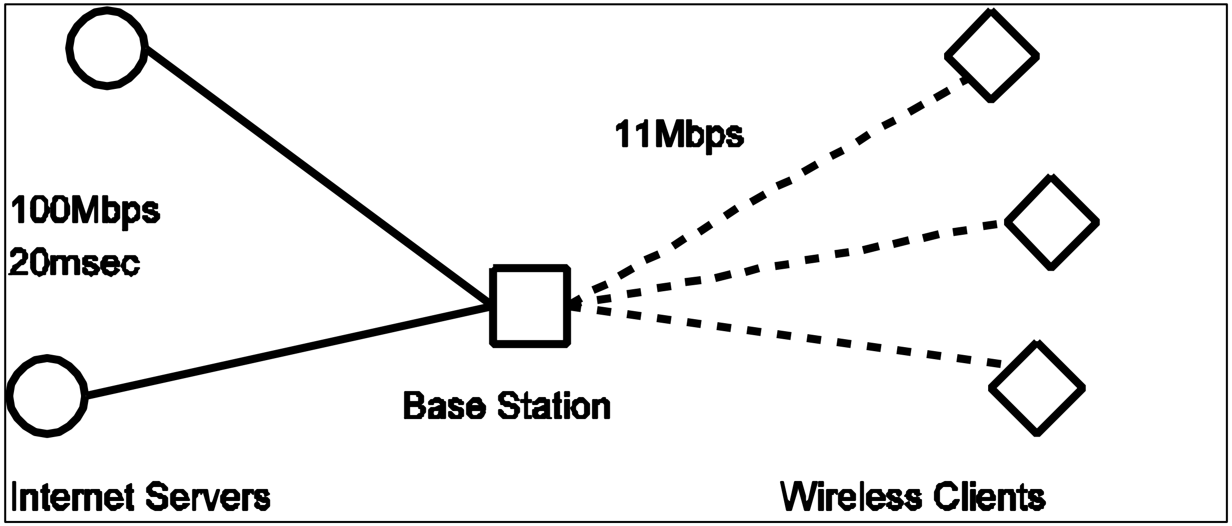
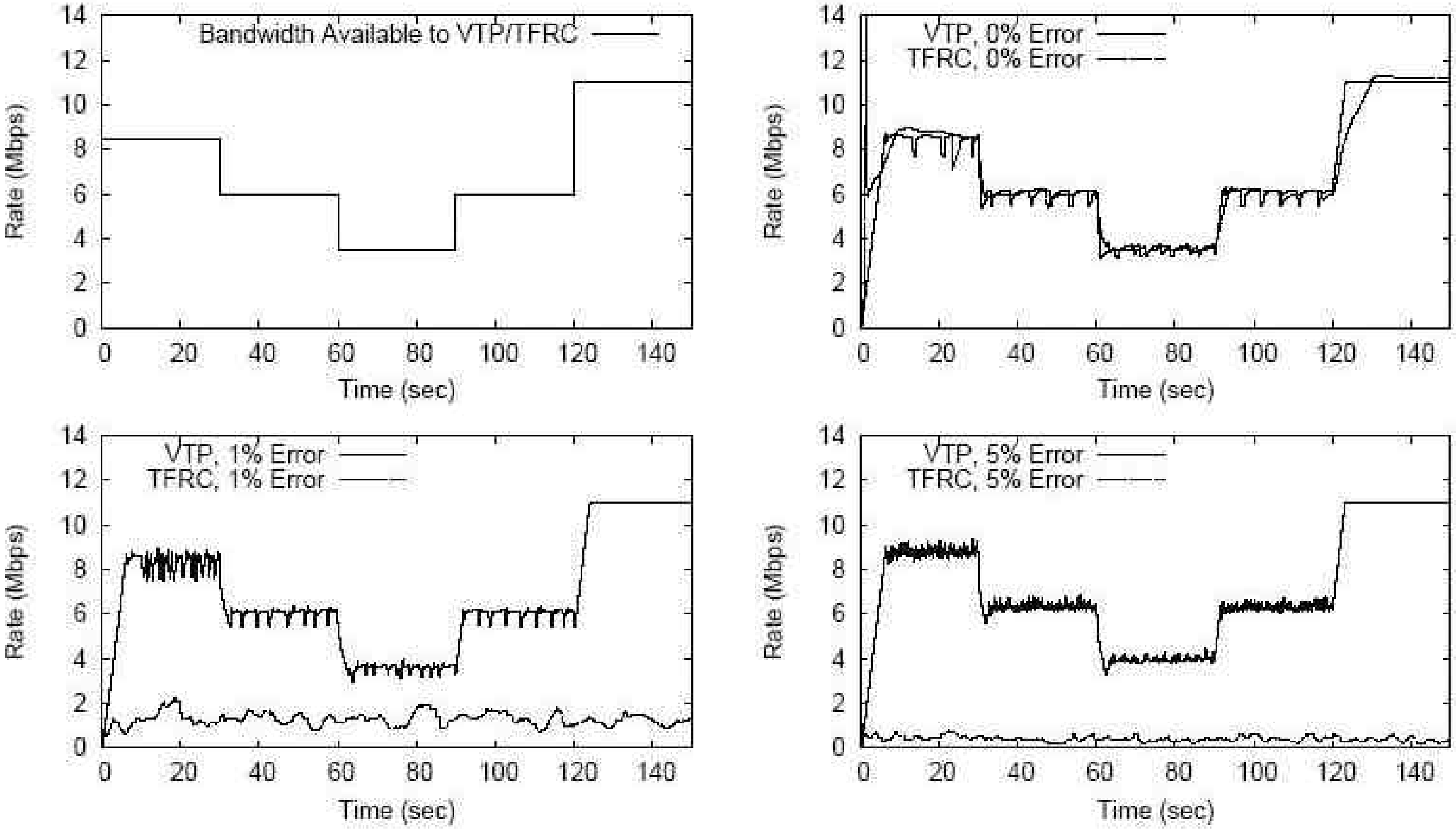



- Mixed wired-wireless scenario
  - All flows go from Internet servers to wireless clients

# Smoothness and Efficiency



# Smoothness and Efficiency (cont'd)

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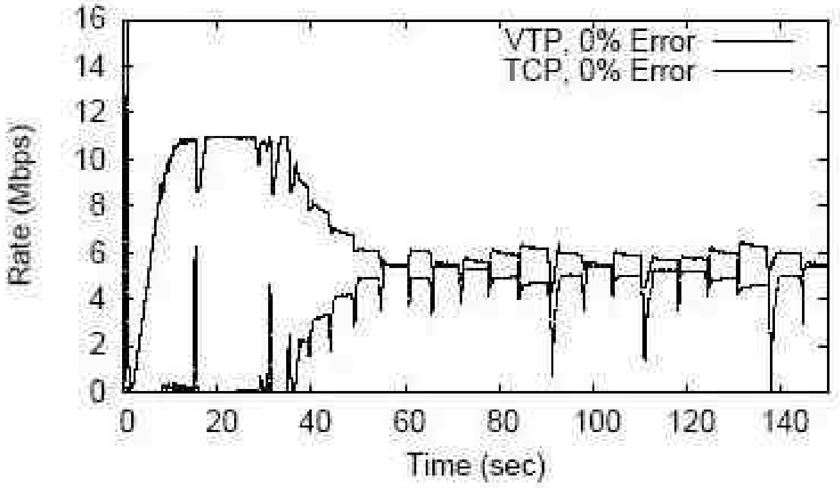
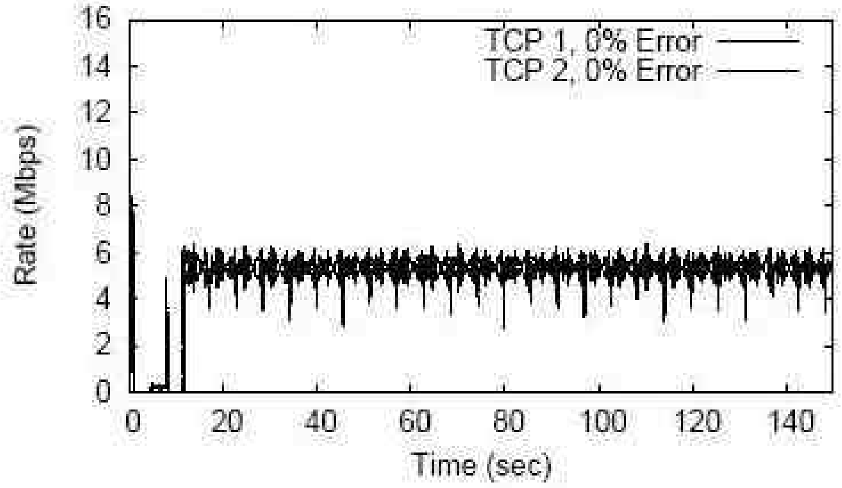
- Previous slide compares "smoothness" and "efficiency" between VTP and TFRC
  - On/off CBR traffic changes the available bandwidth over time
  - Upper-left figure shows the available bandwidth seen by VTP or TFRC flow

- Comparison of VTP and TFRC
  - 0%, 1% and 5% packet error rates are tested
    - 0% and 5% results are shown on next slide
  - VTP retains smoothness and efficiency as error rate grows
  - TFRC has sharply degraded efficiency as error rate grows

# Opportunistic Friendliness




- In 0% error, VTP shares bandwidth equally with TCP
  - TCP overshoots and times out, yielding the poor performance at the beginning
  - VTP/TCP converge to the fair share after TCP ramps up

# Opportunistic Friendliness

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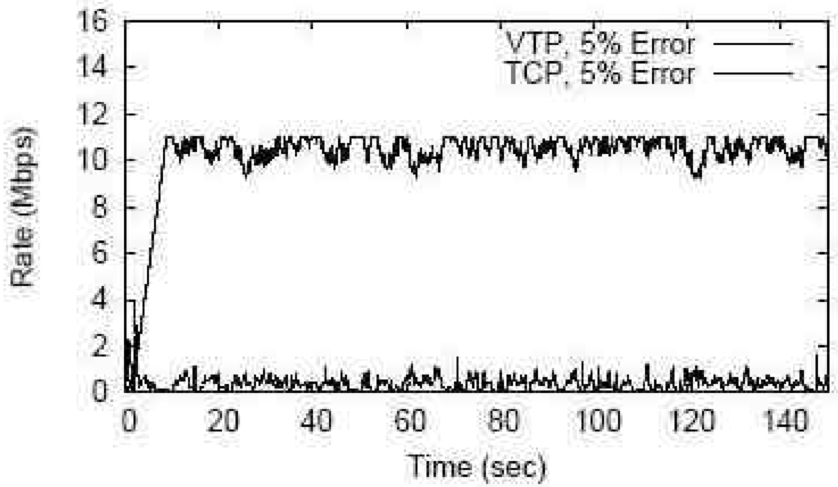


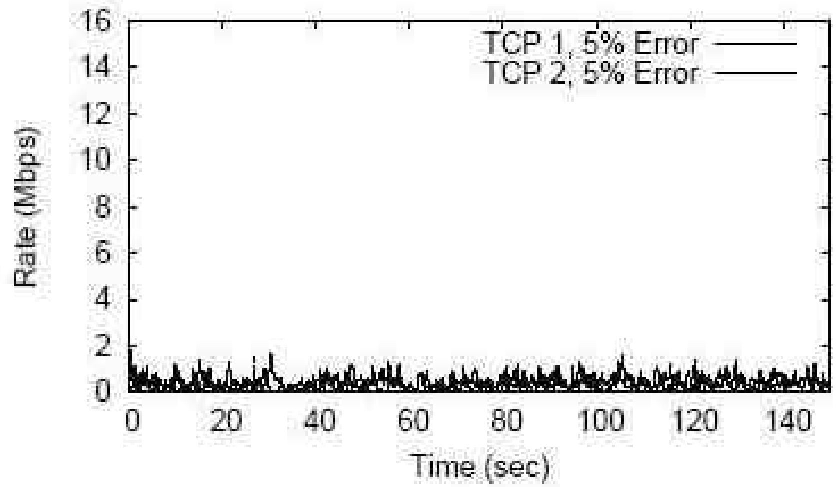


- In 5% error, VTP utilizes bandwidth left by TCP
  - TCP dies by itself with very low throughput
  - VTP picks up "residual" bandwidth that would otherwise become unused
  - We call this "opportunistic friendliness"

# VTP Status

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- VTP is implemented in RTP/RTCP in Windows
- Evaluated in a hybrid simulation testbed
- Ongoing work: VTP as a congestion control option in DCCP

# For More Information

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- [MMNS04] Guang Yang, Mario Gerla and M. Y. Sanadidi, *Adaptive Video Streaming in Presence of Wireless Errors*, The 7th IFIP/IEEE International Conference on Management of Multimedia Networks and Services (MMNS 2004), San Diego, CA, 2004
- [ISCC05] Guang Yang, Ling-Jyh Chen, Tony Sun, Mario Gerla and M. Y. Sanadidi, *Real-time Streaming over Wireless Links: A Comparative Study*, The 10th IEEE Symposium on Computers and Communications (ISCC 2005), Cartagena, Spain, 2005
- A journal submission with more analytic/experimental results is available upon request