Congestion control issues in Real-time Communication- “Sprout” an example

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Agenda

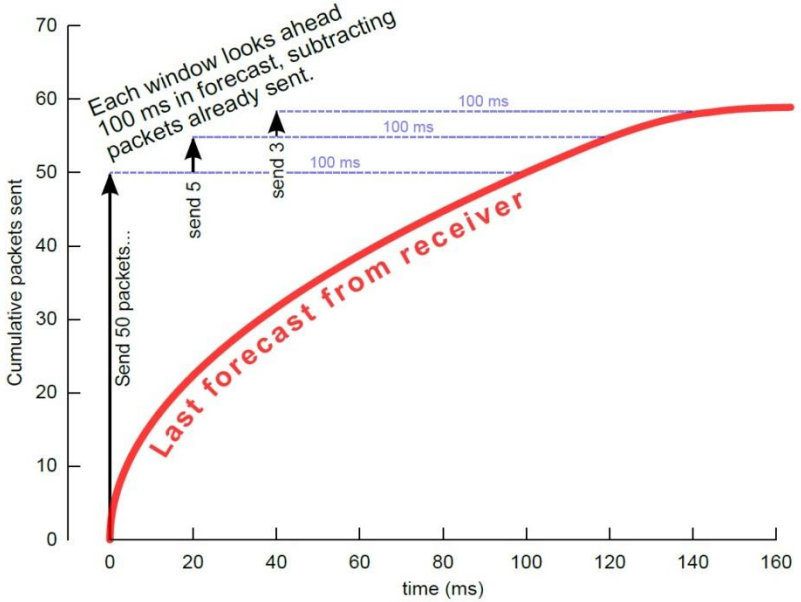
- Background
- Short “Sprout” introduction
- Sprout implementation in LTE simulator
- Simulation scenario
- Evaluation
- Problems
- Conclusion

Background

- There is an effort going on in IETF (RMCAT WG) to standardized congestion control algorithm for Real-Time Conversational media.
- Real-Time Conversational media
  - Demands low delay and loss
  - Typically have periodic media source
    - Frame per seconds are typical units
    - Data limited
- Cellular networks make the task more challenging

“Sprout”

- Introduced by Keith et.al. from MIT
  - Available here http://alfalfa.mit.edu/#
- Transport protocol for real-time applications
- Claims to achieve higher throughput and lower delay over cellular network
- Models network based on trace files

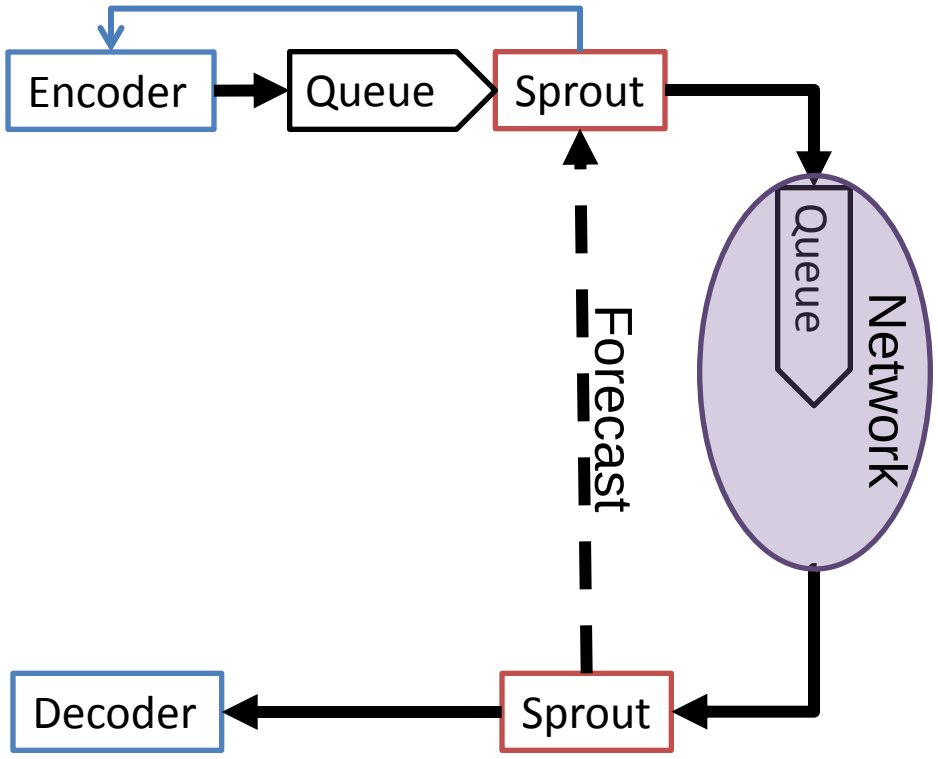


- Throughput measurement (#Packet received every 20 ms – 1Tick)
- Forecast that every packet has 95% probability of clearing network within 100ms

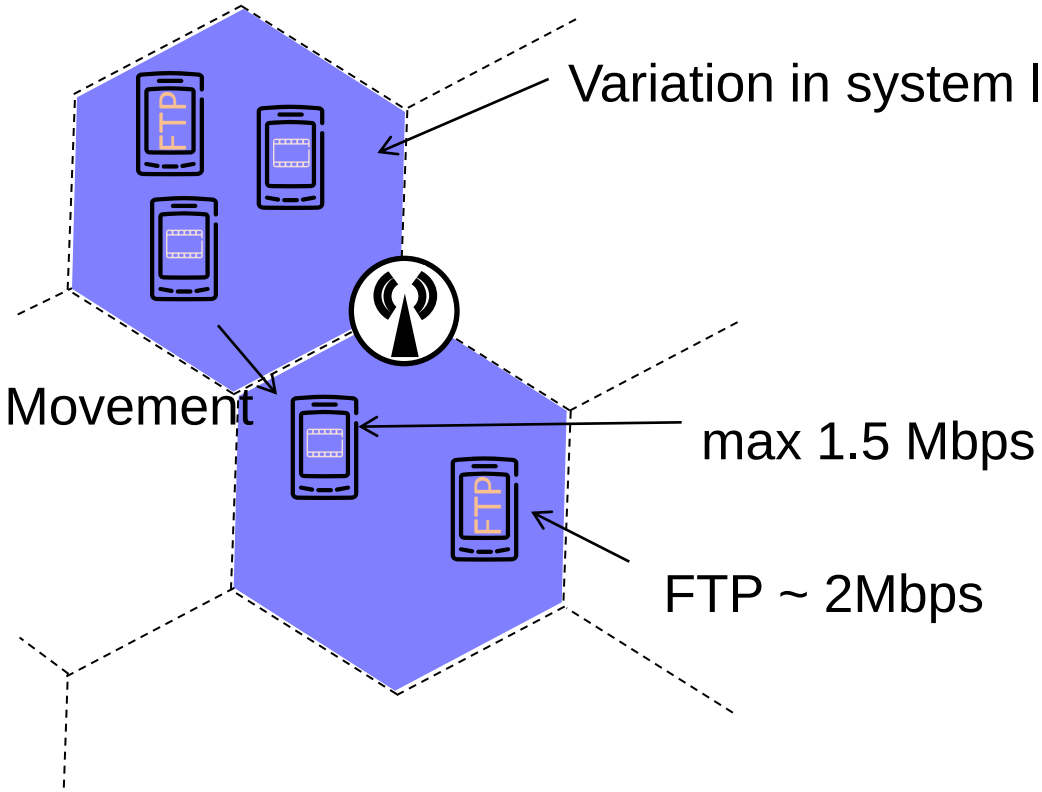
= number of MTU sized packets

“Sprout”- implementation (in simulator)

- Packets are **queued** before Sprout
- Receiver is **measuring** and **forecasting** throughput
- Sender receives forecast and **calculates** network queue size to **fill** the **network**
- Sender sends only if number of packets in queue < forecasted queue size



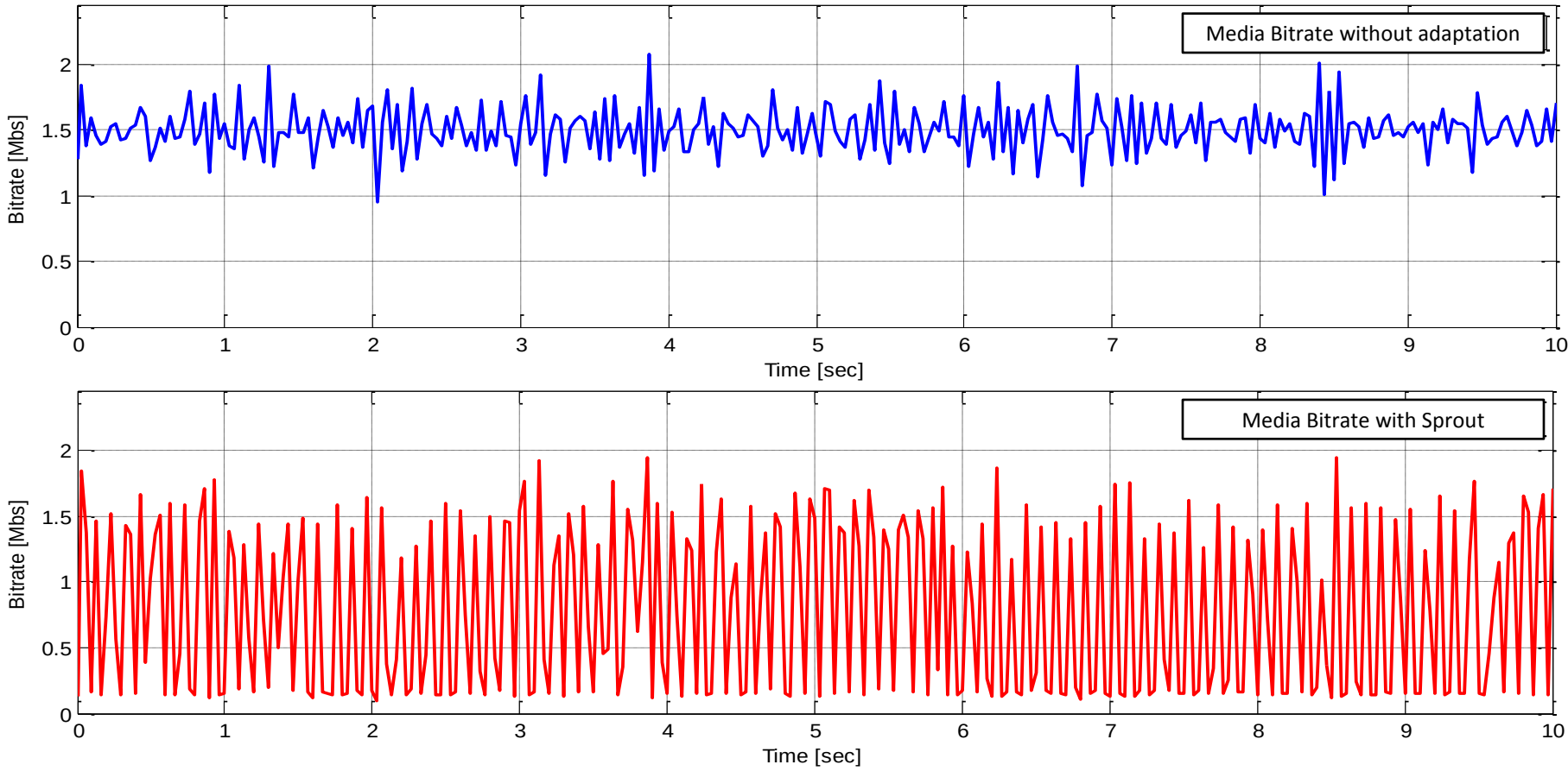
SIMULATION SCENARIO



- Downlink simulation
- 7 base station*3 cells
- 3GPP case 1 SIMO
- Bandwidth: 5MHz
- 3km/h UE speed
- User arrival described through Poisson process
- Video: Nominal bitrate 1500kbps
  - Rate adaptive between 0.2 - 1.5Mbps
  - 30fps
- Video length 60 seconds
- FTP load ~2Mbps/cell
  - Small bursts of 500kb data

Evaluation

- In an uncongested network where sprout is alone in the network
  - unstable



Cause of problem

- False congestion detection
  - Due to periodicity in real-time media source
- “Sprout”
  - Assumes sender has always something to send
  - Has fast feedback loop
    - Updates it forecasting ever 20ms (=1 Tick)
- For conversional video services
  - The **amount of data** to be transmitted can be **limited**
  - The **throughput** can **vary** because of **video** bitrate **not channel capacity**
  - At some point of time there is just **nothing to send to get accurate** forecasting
    - 30fps gives roughly 33ms between frames

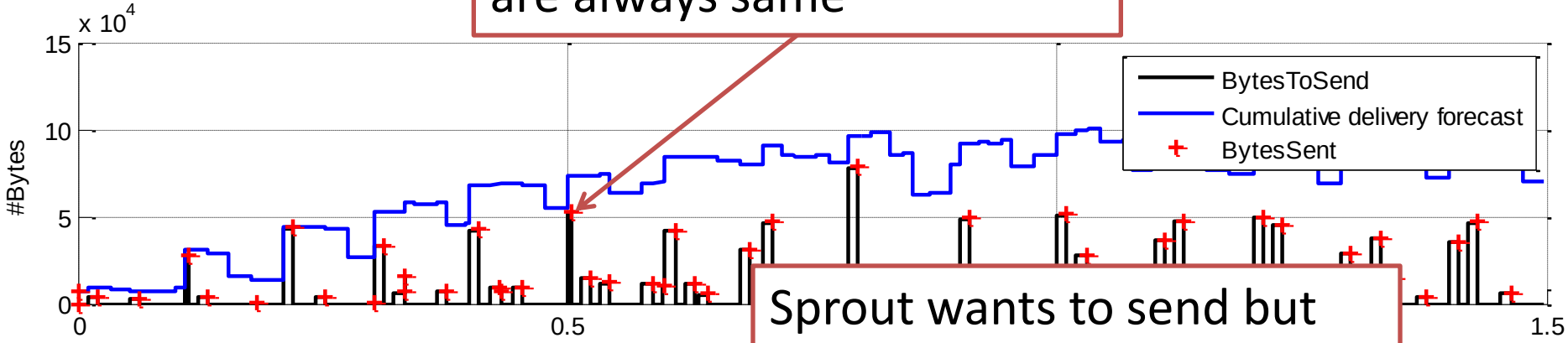
Sprout terminologies

- Cumulative delivery forecast
  - No. bytes which are allowed to **be in the network** at a particular tick
  - Cumulative delivery forecast α 1/Congestion
- Bytes to send
  - Bytes which are allowed **to be send** at this tick
- BytesSend
  - Bytes that are actually send

Forecast vs bytes send

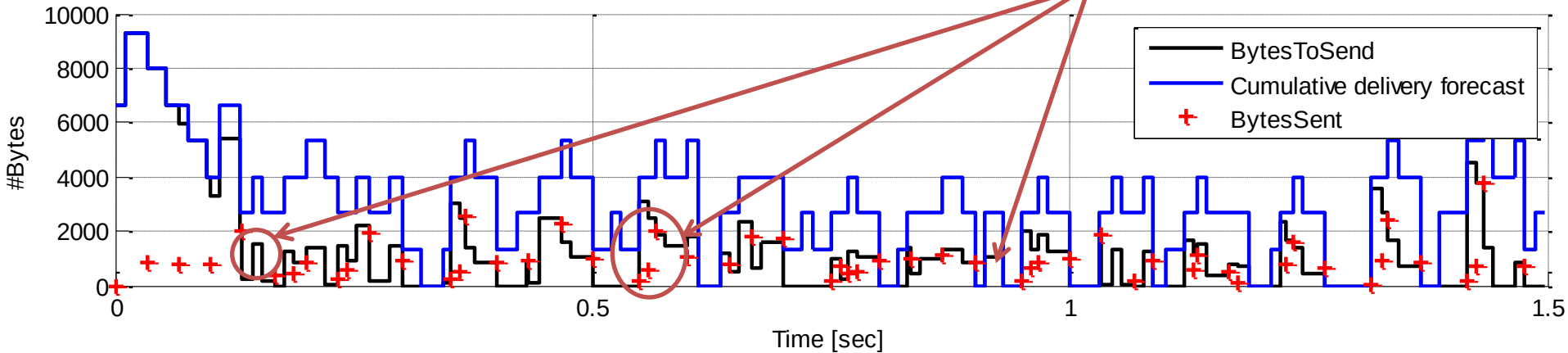
- File Transfer

BytesToSend and BytesSent are always same

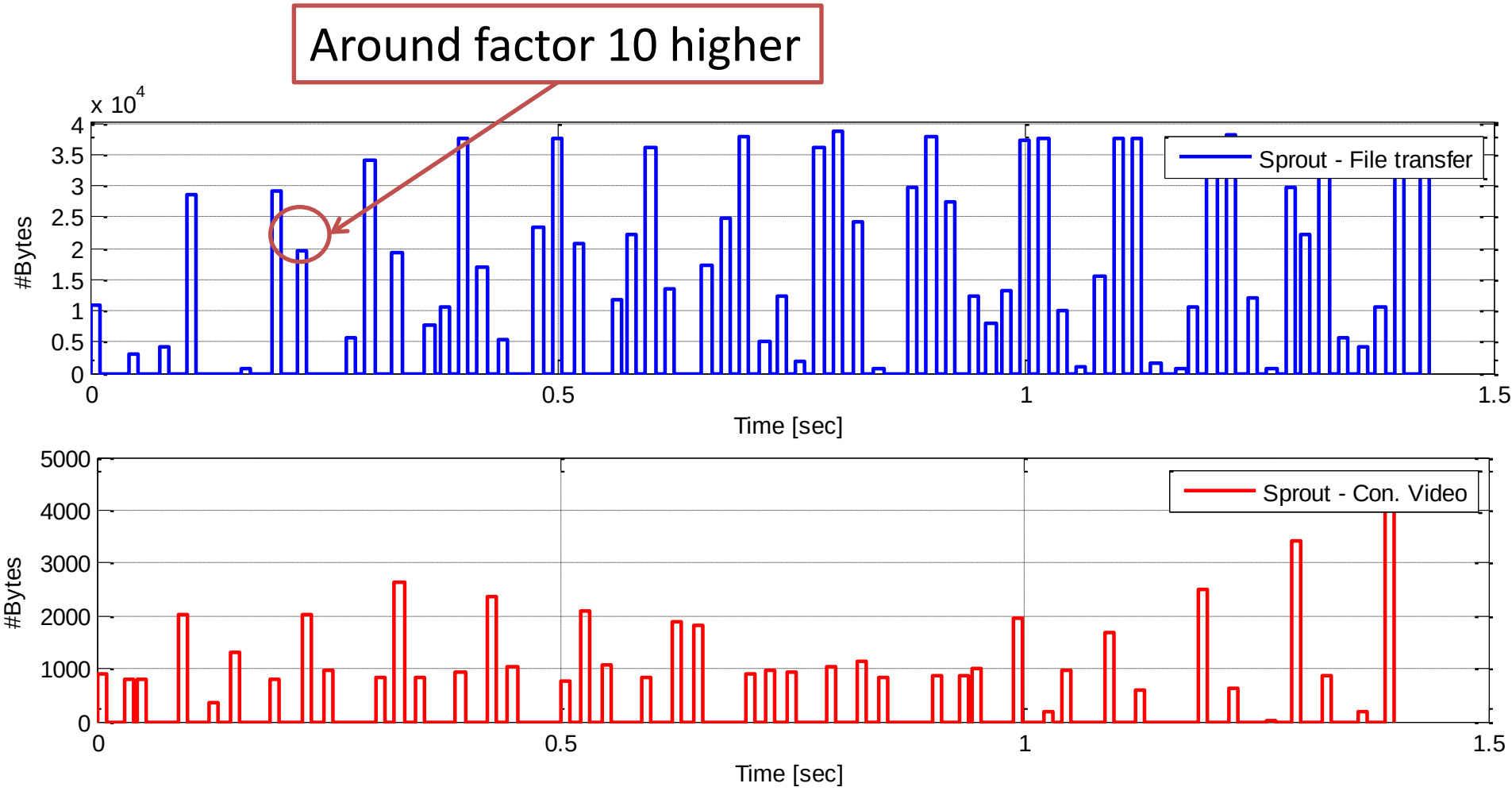


Sprout wants to send but not enough data available to be send

- Conversional Video



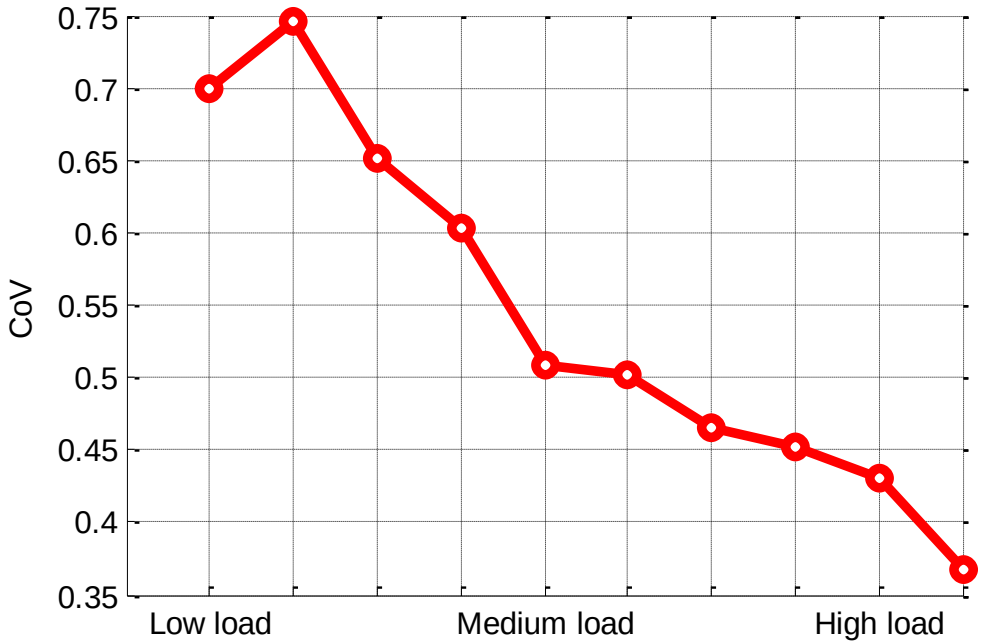
Data reception



In an uncongested network periodicity in data generation leads to unstable behavior in Sprout

Evaluation (with load variation)

- coefficient of variation (CoV) of avg. send video bitrate

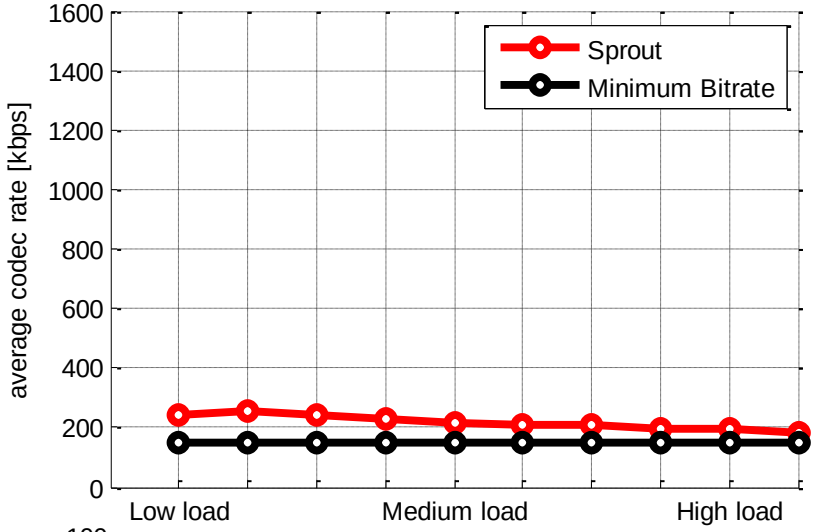


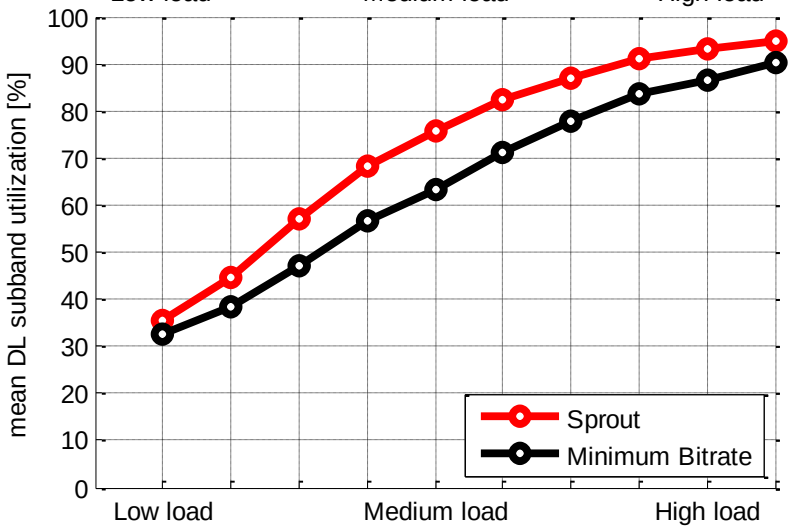
“Sprout” is very unstable

Evaluation (with load variation)

- Video rate adaptation range for “Sprout”
  - 1.5 Mbps-150kbps
- Video bitrate is all most equal to minimum bitrate

“Sprout” doesn’t utilizes the network

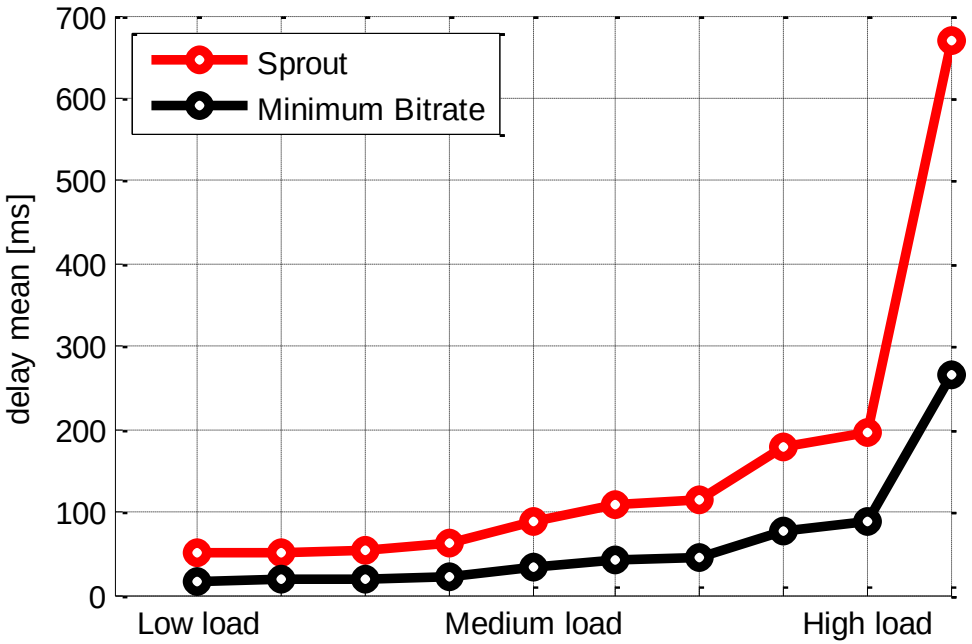




Evaluation (with load variation)

- Even if “Sprout” operates close to the minimum bitrate

“Sprout” adds delay



Sprout is not behaving well in simulated LTE environment

Conclusions

- It is important to consider Rate limited (non-greedy) data source while designing rate control algorithms for real-time conversational communications.
- False congestion detection due to periodicity of media source can lead to
  - Instability, bad network utilization
  - Over all bad performance.
- “Sprout” does not forecast the channel well when it is not congested.