

# TCP Symbiosis: Bio-Inspired Congestion Control Mechanism for High-Speed and Long-Distance Networks

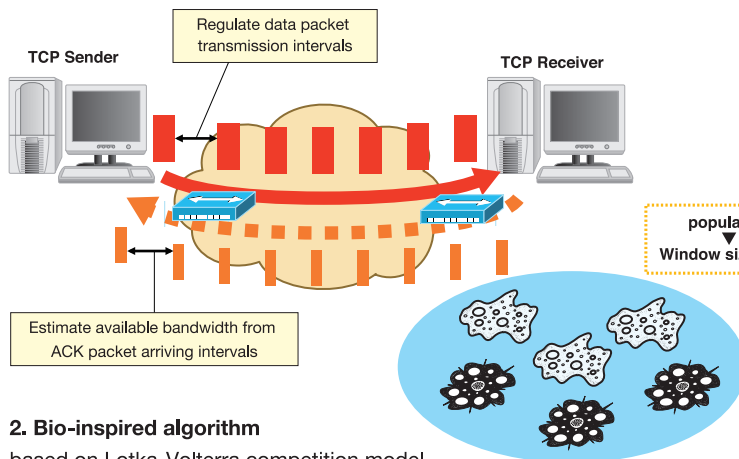
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## Conventional TCP Reno

- Activates congestion control only when detecting packet losses
  - Cannot avoid periodical packet losses even when it behaves ideally
- Fixed parameters for increasing/decreasing transmission speed
  - Very low throughput in high-speed and long-distance networks

## Our method: TCP Symbiosis

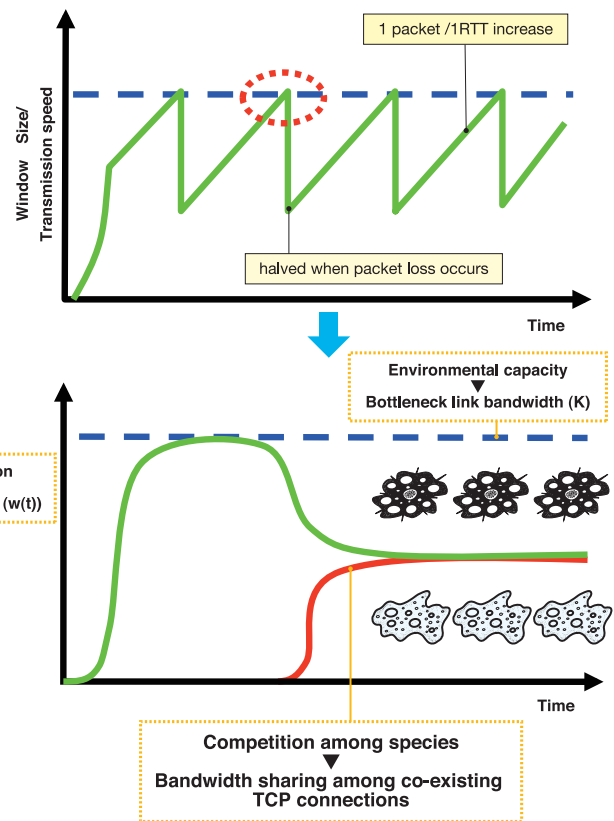
### 1. Inline bandwidth measurement



### 2. Bio-inspired algorithm

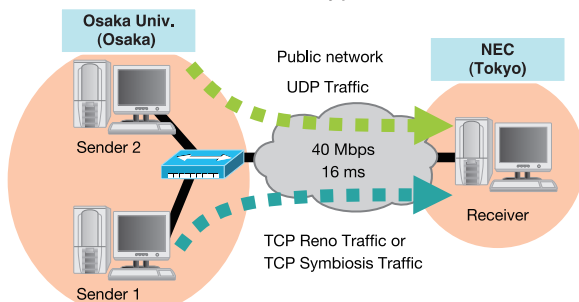
based on Lotka-Volterra competition model

$$\frac{d}{dt} w_i(t) = \varepsilon \left( 1 - \frac{w_i(t) + \gamma (K - A_i) \tau_i}{K \tau_i} \right) w_i(t)$$

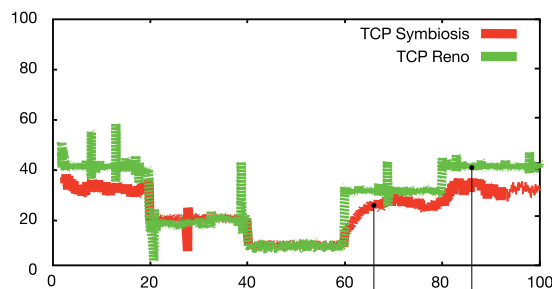


## Results in actual networks

Small bandwidth-delay product network



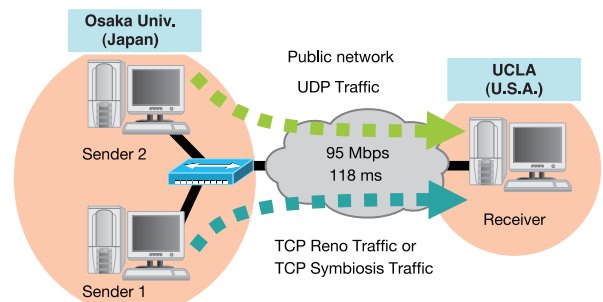
Time (sec)	0-20	20-40	40-60	60-80	80-100
Sender 2	0 Mbps	20 Mbps	30 Mbps	10 Mbps	0 Mbps
Available bandwidth	40 Mbps	20 Mbps	10 Mbps	30 Mbps	40 Mbps



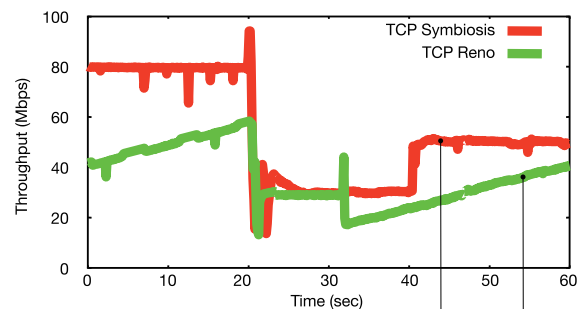
TCP Symbiosis is affected by bandwidth measurement errors

TCP Reno behaves well in this environment

Large bandwidth-delay product network



Time (sec)	0-20	20-40	40-60
Sender 2	15 Mbps	65 Mbps	45 Mbps
Available bandwidth	80 Mbps	30 Mbps	50 Mbps



TCP Symbiosis can accommodate high-bandwidth and long-distance networks

TCP Reno fails to fully utilize available bandwidth