LEDBAT architecture framework consisting of pluggable components

draft-mayutan-ledbat-congestionarchitecture-00.txt

Mayutan Arumaithurai, Xiaoming Fu, K.K Ramakrishnan

March 22, 2010

LEDBAT design goals

1. Saturate bottleneck
2. Keep delay low
3. Yield to traffic using standard TCP
4. Add little to queuing delays
5. Operate well with FIFO and DROP tail queues
6. Be deployable for popular applications
7. Use ECN, AQM, DiffServ where applicable

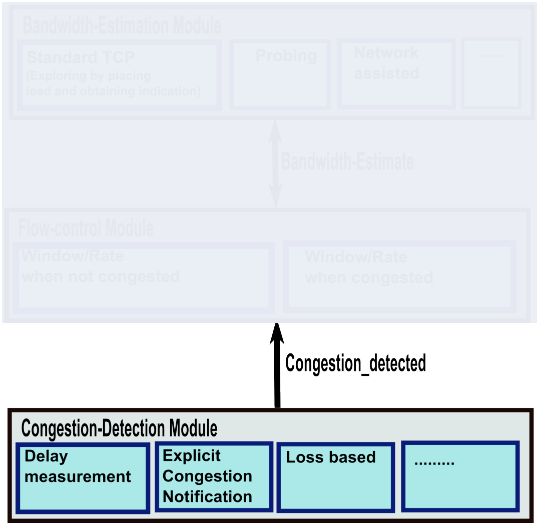
Bandwidth-Estimation Module
Standard TCP
(Exploring by placing load and obtaining indication)
Probing
Network assisted
....
Bandwidth-Estimate
Flow-control Module
Window/Rate when not congested
Window/Rate when congested
Congestion_detected
Congestion-Detection Module
Delay measurement
Explicit Congestion Notification
Loss based
....

Figure: Architecture consisting of pluggable components

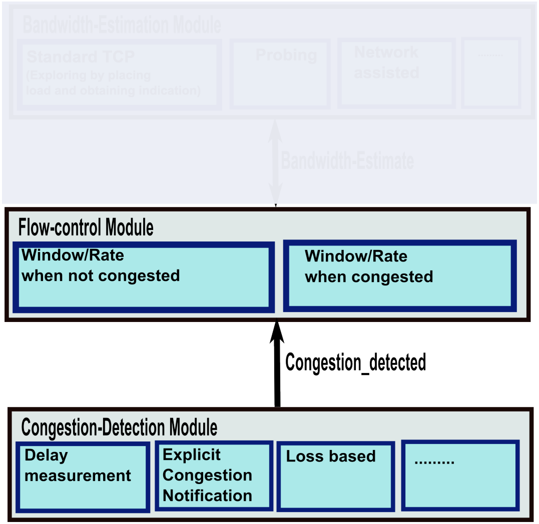
Bandwidth-Estimation Module
Standard TCP
(Exploring by placing load and obtaining indication)
Probing
Network assisted
....
Bandwidth-Estimate
Flow-control Module
Window/Rate when not congested
Window/Rate when congested
Congestion_detected
Congestion-Detection Module
Delay measurement
Explicit Congestion Notification
Loss based
....

Figure: Architecture consisting of pluggable components

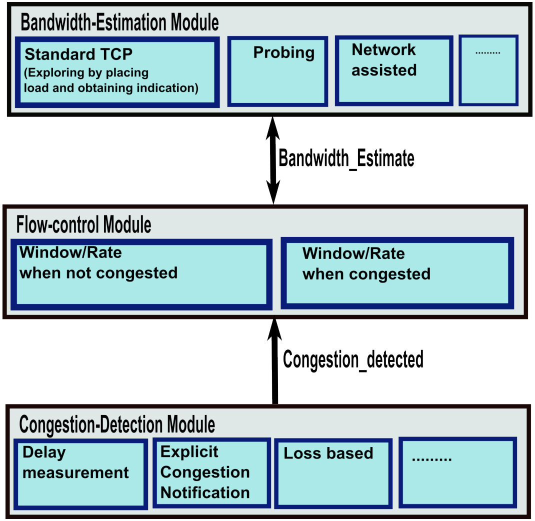
Bandwidth-Estimation Module
Standard TCP
(Exploring by placing load and obtaining indication)
Probing
Network assisted
....
Bandwidth_Estimate
Flow-control Module
Window/Rate when not congested
Window/Rate when congested
Congestion_detected
Congestion-Detection Module
Delay measurement
Explicit Congestion Notification
Loss based
....

Figure: Architecture consisting of pluggable components

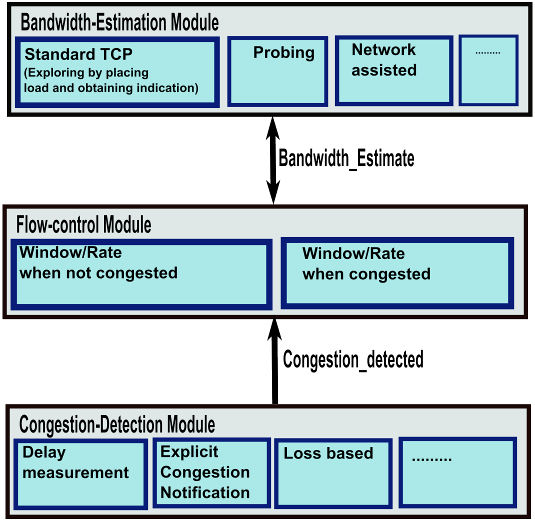
Bandwidth-Estimation Module
Standard TCP (Exploring by placing load and obtaining indication)
Probing
Network assisted
....
Bandwidth_Estimate
Flow-control Module
Window/Rate when not congested
Window/Rate when congested
Congestion_detected
Congestion-Detection Module
Delay measurement
Explicit Congestion Notification
Loss based
....

Figure: Architecture consisting of pluggable components

=> Each module operates in a different timescale

Congestion Detection Module

- Delay Based
    - + Does not require network support
    - − Sensitive to variation in routes, bottleneck buffer size, bursty traffic etc.
- Loss based
    - + Reliable indicator of congestion
    - − Results in substantial interference to TCP
- ECN marking based
    - + Good and early indicator of the onset of congestion
    - − Requires network support
- Delay + Loss/marking based

Congestion Detection Module

- Delay Based
  - + Does not require network support
  - − Sensitive to variation in routes, bottleneck buffer size, bursty traffic etc.
- Loss based
  - + Reliable indicator of congestion
  - − Results in substantial interference to TCP
- ECN marking based
  - + Good and early indicator of the onset of congestion
  - − Requires network support
- Delay + Loss/marking based

Congestion indicator:

- Binary states: congested or non-congested
- Multiple levels: 0, 0.1, .., 0.5, .., 1

Flow Control Module

- Standard TCP (AIMD)
  - + Robust: Good indication of available capacity
  - – Substantial queuing, thereby delay
  - – Conservative in using available bandwidth
- Variants (Aggressive Increase)
- + Good for high BDP networks
  - Without bandwidth estimation
    - – Cause interference: No prior knowledge of available bandwidth
  - With Bandwidth Estimation
    - + Separates congestion control from bandwidth estimation
    - – Slower
    - – Involves additional overhead

Flow Control Module

- Standard TCP (AIMD)
  - + Robust: Good indication of available capacity
  - – Substantial queuing, thereby delay
  - – Conservative in using available bandwidth
- Variants (Aggressive Increase)
- + Good for high BDP networks
  - Without bandwidth estimation
    - – Cause interference: No prior knowledge of available bandwidth
  - With Bandwidth Estimation
    - + Separates congestion control from bandwidth estimation
    - – Slower
    - – Involves additional overhead

=> Always necessary to have an estimate of available bandwidth

Flow Control Module

- Standard TCP (AIMD)
  - + Robust: Good indication of available capacity
  - − Substantial queuing, thereby delay
  - − Conservative in using available bandwidth
- Variants (Aggressive Increase)
- + Good for high BDP networks
  - Without bandwidth estimation
    - − Cause interference: No prior knowledge of available bandwidth
  - With Bandwidth Estimation
    - + Separates congestion control from bandwidth estimation
    - − Slower
    - − Involves additional overhead

=> Always necessary to have an estimate of available bandwidth

=> More useful in the context of LEDBAT, due to submissive nature

Bandwidth Estimation Module

- Standard TCP (increase until loss)
- Delay based (e.g Vegas, Compound TCP)
- Probing based
- Router assisted (e.g. Quick start)
- Support of some oracle server

LEDBAT example - 1

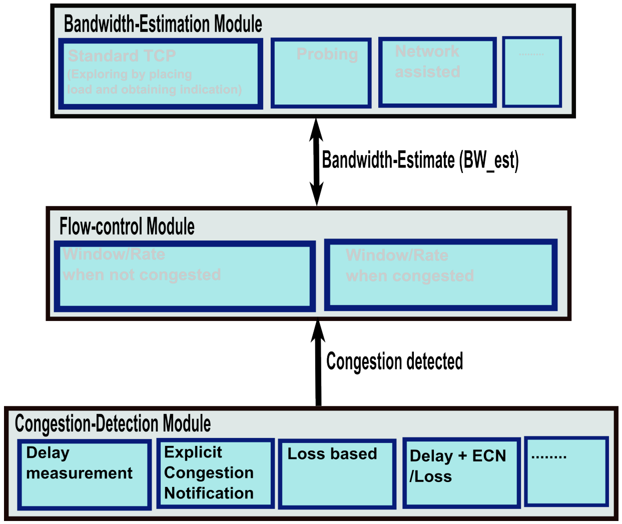
Bandwidth-Estimation Module
Standard TCP
(Exploring by placing load and obtaining indication)
Probing
Network assisted
....
Bandwidth-Estimate (BW_est)
Flow-control Module
Window/Rate when not congested
Window/Rate when congested
Congestion detected
Congestion-Detection Module
Delay measurement
Explicit Congestion Notification
Loss based
Delay + ECN /Loss
....

Figure: LEDBAT example with varying Congestion detection components

LEDBAT example - 2

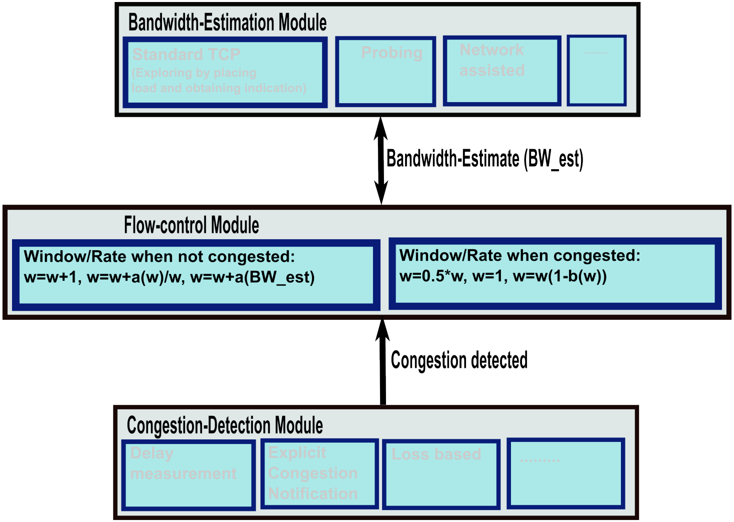
Bandwidth-Estimation Module
Standard TCP
(Exploring by placing
load and obtaining indication)
Probing
Network
assisted
....
Bandwidth-Estimate (BW_est)
Flow-control Module
Window/Rate when not congested:
w=w+1, w=w+a(w)/w, w=w+a(BW_est)
Window/Rate when congested:
w=0.5*w, w=1, w=w(1-b(w))
Congestion detected
Congestion-Detection Module
Delay
measurement
Explicit
Congestion
Notification
Loss based
....

Figure: LEDBAT example with varying flow control components

LEDBAT example - 3

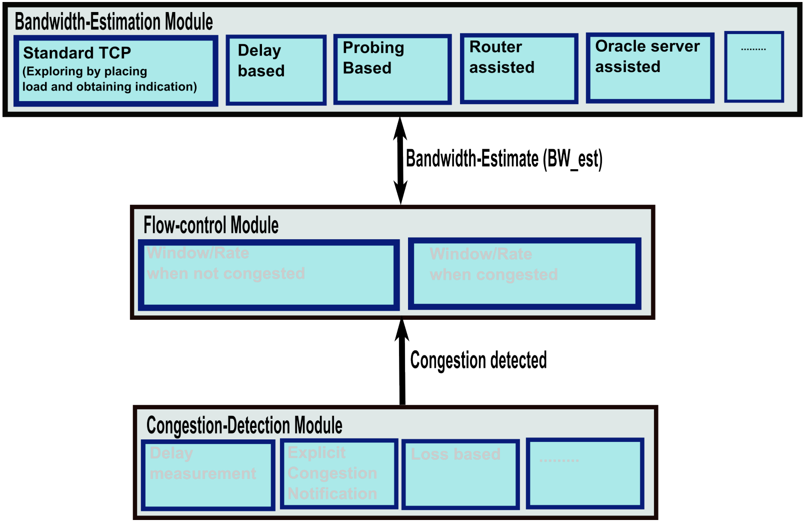
Bandwidth-Estimation Module
Standard TCP
(Exploring by placing load and obtaining indication)
Delay based
Probing Based
Router assisted
Oracle server assisted
....
Bandwidth-Estimate (BW_est)
Flow-control Module
Window/Rate when not congested
Window/Rate when congested
Congestion detected
Congestion-Detection Module
Delay measurement
Explicit Congestion Notification
Loss based
....

Figure: LEDBAT example with varying bandwidth estimation components

Conclusion

- We could use it as a guideline while standardizing a CC mechanism to keep it flexible.
- Each module and component can be independently standardized
    - Decoupling each module
- Often implicitly followed in current specifications