ABR Engineering: Guidelines for Setting ABR Parameters

Raj Jain

Raj Jain is now at
Washington University in Saint Louis
Jain@cse.wustl.edu
http://www.cse.wustl.edu/~jain/

http://www.cis.ohio-state.edu/~jain/talks/cng_prm.htm

ABR Parameters

Label	Expansion	Units and Range	Default Value	Signaled?
PCR	Peak Cell Rate	Cells/second from 0 to 16M	-	down
MCR	Minimum Cell Rate	Cells/second from 0 to 16M	0	down to MCRmin
ACR	Allowed Cell Rate	Cells/second from 0 to 16M	-	no
ICR	Initial Cell Rate	Cells/second from 0 to 16M	PCR	Down
TCR	Tagged Cell Rate	Constant	10 cells/s	no
Nrm	Number of cells between FRM cells	Power of 2 from 2 to 256	32	optional
Mrm	Controls bandwidth allocation between FRM, BRM and data cells	Constant	2	No
Trm	Upper Bound on Inter-FRM Time	Milliseconds, 100 times power of 2 from -7 to 0	100 ms	Optional

ABR Parameters (cont'd)

Label	Expansion	Units and Range	Default Value	Signaled?
RIF	Rate Increase Factor	Power of 2 from 1/32768 to 1	1	Down
RDF	Rate Decrease Factor	Power of 2 from 1/32768 to 1	1/32768	Up
ADTF	ACR Decrease Time Factor	Seconds, from 0.01 to 10.23 seconds in steps of 10 ms	500 ms	optionally down
TBE	Transient Buffer Exposure	Cells from 0 to 16,777,215	16,777,215	down
CRM	Missing RM-cell Count	Integer of unspecified size	Celing of TBE/ Nrm	computed
CDF	Cutoff Decrease Factor	Zero or a power of 2 from 1/64 to 1	1/16	optionally up
FRTT	Fixed Round-Trip Time	Microseconds from 0 to 16.7 seconds		accumulated

Peak Cell Rate (PCR)

- Allowed Cell Rate (ACR) ≤ PCR
- Set by source according to its own capacity, and according to pricing
- Reduced by switches according to the bandwidth of the links on the path from the source to the destination
- Dependent on bottleneck link bandwidth, but not on round trip time
- Charging considerations may limit PCR = k×MCR, k=2 to 10 (Shaping required in ABR)

Minimum Cell Rate (MCR)

- Allowed Cell Rate (ACR) ≥ MCR
- Set by source according to its application type (e.g., video applications need a certain MCR), and according to pricing. Can be zero for best effort traffic
- Reduced by switches according to the CAC algorithm, e.g., MCRi = min (MCRi in RM cell, link bandwidth - CBR PCRs - VBR SCRs - ABR MCRs). Connection rejected if MCR < MCRmin
- Dependent on bottleneck link bandwidth, but not on round trip time
- Most applications/TCP perform better w MCR >0

Number of RM (Nrm)

- An RM cell is sent every Nrm - 1 data cells
- Nrm ranges from 2 to 256, with default 32
- Small Nrm $\Rightarrow$ high responsiveness, but also high overhead and high frequency rate variations
- Nrm should be larger if sources or switches have limited capacity, or if traffic is real-time, and hence minimal rate variations are desired

Nrm (Cont)

Total ABR Capacity	OC-3 155 Mbps	OC-24 1.2 Gbps	T1 1.5 Mbps	DS0 64 kbps
Inter-cell time	3 μs	0.37 ms	3 ms	72 ms
Inter-RM Nrm=32	96 μs	12 μs	96 ms	2.3 s
Inter-RM NRM=256	768 μs	96 μs	768 ms	18.4s
Inter-RM NRM=8	24 μs	3 μs	24 ms	0.5 s

- Use 32 below OC-3
- Use 256 for OC-3 and above

Time before RM (Trm)

- Trm is the time to wait before sending an RM cell since last FRM (for low rate sources), assuming at least 2 data cells have been sent since last FRM
- Small Trm ⇒ high responsiveness, but also high overhead ⇒ set according to application type. See Fig 6. Particularly if ABR capacity has no minimum.
- Trm should decrease with the increase of speed (PCR)
- Trm is independent of the round trip time

Rate Increase Factor (RIF)

- Determines maximum rate increase when a BRM cell indicating underload is received (maximum increase is RIF times PCR)
- Although RIF is independent of speed and round trip time, it should be more conservative with higher speed and RTT
- EFCI and RRM switches, and ER switches sensitive to RIF should reduce it, depending on the PCR, RTT and the scheme

Rate Decrease Factor (RDF)

- Determines rate decrease when a BRM cell indicating overload is received (decrease is by subtracting (ACR times RDF) from ACR
- Although RDF is independent of speed and round trip time, it should be more conservative with higher speed and RTT
- Only switches which set EFCI or the CI bit need to reduce RDF, with increasing PCR, RTT and the scheme

Transient Buffer Exposure (TBE)

- TBE determines the exposure of the switch to sudden traffic transients, since it affects the value of CRM and of ICR
- TBE should be set according to the product of the PCR and the RTT, and according to buffer availability (it increases with the increase of all of these). See Fig 10.
- If there are satellite links or very high speed links on the path, TBE should not be reduced much
- No effect on buffers. See Fig 11-12.

Initial Cell Rate (ICR)

- ICR determines the rate at which the source sends at the start of the connection and after long idle periods
- The source sets ICR according to its own capacity, application type and pricing
- Switch reduces it depending on available buffering, bandwidth and resources
- Source takes the minimum of the signaled ICR and TBE/FRTT
- ICR should be close to PCR (TCP window will be 1) at least for OC-3 and below

Cutoff Decrease Factor (CDF)

- Determines the exponential rate decrease from source rule 6
- Set more conservatively (smaller) for high speeds or long round trip times
- Depends on the confidence in the TBE value in addition to application type and availability of resources

ACR Decrease Time Factor (ADTF)

- After ADTF seconds, ACR is set to ICR
- Independent of speed and round trip time.
  Smaller value for larger speed links(? Not required due to smoothing) (not much overhead and large dynamics)
  Larger value for larger RTT. ADTF> RTT
- Set according to expected application traffic characteristics (burstiness) and availability of resources
- 500 ms is based on TCP slow start rule.

Tagged Cell Rate (TCR)

- Out of rate FRM cells are upper-bounded by TCR
- Small TCR $\Rightarrow$ faster transient response when ACR goes to zero, but also higher overhead
- Depends on bottleneck link speed
  Larger values with larger speed
- Same parameter used by switches for BECN.
  Larger BECN rate at high speed will help.

ABR Parameter Guidelines

Parameter	Speed	RTT?	Source initializes according to	Switch modifies according to
PCR	Increases	no effect	Link bandwidth or host/application capacity and pricing	bottleneck link bandwidth
MCR	Increases	no effect	Application requirements (e.g, video) and pricing	connection admission control (available resources)
ICR	Increases	Source takes min (ICR, TBE/FRTT)	Pricing, host capacity and application	depends on buffering and resources
Nrm	no, but maybe should increase with speed	no effect	Application type (real-time should increase it)	according to switch scheme
Trm	Decreases	no effect	Application type	switches can reduce Trm for a high PCR

ABR Parameter Guidelines

Parameter	Speed	RTT?	Source initializes according to	Switch modifies according to
RIF	no, but may be decreased	no, but may be decreased	Depends on application	EFCI and RRM switches and ER switches sensitive to RIF should reduce it depending on FRTT, PCR and scheme
RDF	no, but may be decreased	no, but may be decreased	Depends on application	EFCI and RRM switches should reduce dependent on FRTT, PCR and scheme
ADTF	no effect	no effect May increase	Application traffic characteristics	if less available resources, reduce ADTF
TBE	Increases	Increases	Depends on the application type, pricing and host capacity	depends on buffering and resources, and PCR and FRTT
CDF	may be smaller for high speeds	May be smaller for long RTTs	Application type, confidence in TBE value	confidence in TBE value, confidence in links, availability of resources