Fairness Considerations for Congestion Control
for Interactive Real-Time Communication (IRTC)

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In response to the call for papers for the IAB/IRTF Workshop to be held on July 28, 2012 in Vancouver, Canada, the following fairness considerations, particularly to TCP, should be discussed in the workshop and subsequent work toward solutions.

1. TCP Friendly Rate Control (TFRC) [RFC 5348] is the most-often referenced, but not-so-often deployed, model of fairness for IRTC traffic competing with TCP flows. However, TFRC has some drawbacks, some of which are inherent to TCP itself.

a. The throughput TFRC can achieve is limited by the loss event rate and round trip time. The consequence for TFRC senders is they will be unable to send high quality media (HD or Full HD) at moderate loss rates and RTTs, which are not uncommon in real world scenarios such as intercontinental links, wireless links, or links with large buffer delays. The figure below illustrates this limitation. (TFRC parameters used are b=1, t_RTO=4RTT, MSS=1460.)

TFRC Rate (kbps) based on Loss (%) and RTT (ms)

RTT(ms)	0.01%	0.05%	0.1%	0.5%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
900	1588	708	498	215	146	95	72	58	48	40	35	30	26	23
800	1787	796	560	242	164	107	81	65	54	46	39	34	30	26
700	2042	910	640	277	187	122	92	74	62	52	45	39	34	30
600	2382	1061	747	323	219	143	108	86	72	61	52	45	39	34
500	2858	1274	897	387	262	171	129	104	86	73	63	54	47	41
400	3573	1592	1121	484	328	214	162	130	108	91	78	68	59	52
350	4083	1820	1281	553	375	244	185	148	123	104	89	77	67	59
300	4764	2123	1494	645	437	285	215	173	144	121	104	90	79	69
250	5717	2547	1793	774	525	342	259	208	172	146	125	108	94	83
200	7146	3184	2242	968	656	428	323	259	215	182	156	135	118	103
150	9528	4246	2989	1291	875	570	431	346	287	243	209	181	157	138
100	14292	6369	4483	1936	1312	856	646	519	431	364	313	271	236	207
75	19056	8492	5978	2581	1749	1141	862	692	574	486	417	361	315	276
50	28584	12737	8967	3872	2624	1711	1293	1038	861	729	626	542	472	413
25	57169	25475	17933	7743	5248	3422	2585	2076	1722	1458	1251	1083	944	827

Loss(%)

Video Quality Color Code:

FHD >2M

HD 1-2M

SD ~500k

LD <300k

b. Another drawback is that TFRC models a relatively old TCP: Reno without SACK. Modern TCPs (CTCP, BIC, CUBIC), which some studies show to be more predominant on the Internet than classical Reno, may or may not be modeled well by TFRC. IRTC should be fair to which TCP?

c. The mechanics of TFRC require high frequency feedback, which is not usually suitable for RTCP even under AVPF rules [RFC 4585]. Lowering the feedback frequency can impact fairness.

d. A more fundamental argument against TCP friendliness in general, not just specifically TFRC, is the questionable assumption of fairness via equal flow rates between a single TCP flow and a media flow which may even contain multiplexed streams. A typical webpage results in 10+ TCP flows. Many background processes have many open TCP connections, some of which are actively flowing.

In this context, it may be more fair to allow the media flow to weight itself more heavily than a single TCP flow, if it is the primary foreground activity. This argues for weighted fairness with application specified weights.

2. MulTFRC [draft-irtf-iccrg-multfrc] can model weighted fairness with N TCP flows, where N can be fractional and/or <1. Most of the TFRC issues remain, but the model is better than NxTFRC, and claims to improve on TFRC even for N=1. The figures below illustrate N=2 and N=4, where high quality media can be sent for much larger ranges of loss rates and RTTs. (MulTFRC parameter j=1.)

MulTFRC Rate (kbps) based on Loss (%) and RTT (ms) for N=2

RTT(ms)	0.01%	0.05%	0.1%	0.5%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
900	3178	1419	1002	442	307	209	164	136	116	100	86	74	63	52
800	3575	1597	1127	497	345	235	185	153	130	112	97	83	71	59
700	4086	1825	1288	568	395	269	211	175	149	128	111	95	81	67
600	4767	2129	1503	663	461	314	246	204	173	149	129	111	94	79
500	5720	2555	1803	795	553	377	296	245	208	179	155	133	113	94
400	7150	3193	2254	994	691	471	369	306	260	224	193	166	142	118
350	8172	3649	2576	1136	790	538	422	350	297	256	221	190	162	135
300	9533	4258	3005	1326	921	628	493	408	347	299	258	222	189	157
250	11440	5109	3607	1591	1105	754	591	490	416	358	309	266	227	189
200	14300	6386	4508	1989	1382	942	739	612	520	448	387	333	283	236
150	19067	8515	6011	2652	1842	1256	985	816	694	597	516	444	378	315
100	28600	12773	9016	3977	2764	1884	1478	1224	1041	896	774	666	566	472
75	38134	17031	12022	5303	3685	2512	1970	1632	1388	1194	1031	887	755	629
50	57201	25546	18033	7955	5527	3768	2956	2448	2081	1791	1547	1331	1133	944
25	114401	51092	36066	15909	11055	7535	5911	4896	4163	3583	3094	2662	2265	1888
Loss(%)														

Video Quality Color Code:

- FHD >2M
- HD 1-2M
- SD ~500k
- LD <300k

MulTFRC Rate (kbps) based on Loss (%) and RTT (ms) for N=4

RTT(ms)	0.01%	0.05%	0.1%	0.5%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
900	6362	2845	2010	889	618	421	330	272	230	196	167	141	117	93
800	7157	3200	2261	1000	696	474	371	306	258	220	188	159	131	105
700	8180	3657	2584	1143	795	542	424	350	295	252	215	181	150	120
600	9543	4267	3014	1333	927	632	495	408	344	294	250	211	175	140
500	11451	5120	3617	1600	1113	758	593	489	413	352	300	254	210	168
400	14314	6400	4521	2000	1391	948	742	612	517	441	376	317	263	210
350	16359	7314	5167	2286	1590	1083	848	699	590	504	429	362	300	240
300	19086	8534	6029	2666	1855	1264	989	816	689	587	501	423	350	280
250	22903	10240	7234	3200	2226	1517	1187	979	827	705	601	507	420	336
200	28629	12800	9043	4000	2782	1896	1484	1223	1033	881	751	634	525	420
150	38172	17067	12057	5333	3710	2528	1978	1631	1378	1175	1001	846	700	560
100	57257	25601	18086	7999	5564	3792	2967	2447	2067	1762	1502	1269	1051	840
75	76343	34134	24115	10666	7419	5055	3956	3262	2756	2350	2003	1692	1401	1121
50	114515	51201	36172	15999	11129	7583	5934	4894	4133	3525	3004	2537	2101	1681
25	229029	102403	72344	31998	22258	15166	11868	9787	8267	7049	6009	5075	4202	3362
Loss(%)														

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a. However, it should be noted that MulTFRC is close to NxTFRC (within 30%) at random, non-bursty (j=1) loss rates below 10% as shown in the figure below. This brings into question whether the added complexity of MulTFRC over NxTFRC is justified. Note that there is rather severe oscillation beyond 10%.

MulTFRC vs. NxTFRC relative rate (%) based on Loss (%) and Number of Flows (N)

N	0.01%	0.05%	0.1%	0.5%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	20%	40%	80%	Loss(%)
50	0%	1%	1%	4%	7%	11%	15%	17%	19%	18%	15%	10%	0%	-14%	-80%	-51%	32%	
20	0%	1%	1%	4%	7%	11%	15%	17%	19%	18%	16%	11%	2%	-11%	-80%	-51%	32%	
10	0%	1%	1%	4%	6%	11%	15%	18%	19%	19%	17%	13%	5%	-8%	-80%	-51%	32%	
6	0%	1%	1%	3%	6%	11%	15%	18%	20%	20%	19%	15%	8%	-3%	-80%	-51%	32%	
5	0%	1%	1%	3%	6%	11%	15%	18%	20%	20%	19%	16%	9%	-1%	-80%	-51%	32%	
4	0%	0%	1%	3%	6%	11%	15%	18%	20%	21%	20%	17%	11%	2%	-80%	-51%	32%	
3	0%	0%	1%	3%	6%	11%	15%	18%	20%	22%	21%	19%	14%	6%	-80%	-51%	32%	
2	0%	0%	1%	3%	5%	10%	14%	18%	21%	23%	24%	23%	20%	14%	-80%	-51%	32%	
1	0%	0%	0%	2%	4%	8%	13%	17%	21%	24%	27%	29%	30%	30%	-80%	-51%	32%	

MulTFRC rate is close to NxTFRC rate (within 30%) when loss <10%. Severe oscillation when loss >10%.

3. In summary, some form of application-specified weighted fairness is essential, either via MulTFRC, NxTFRC, or other algorithms. Also, the known issues with TFRC should also be addressed before using it as a basis for a fairness model.