Congestion Control Workshop

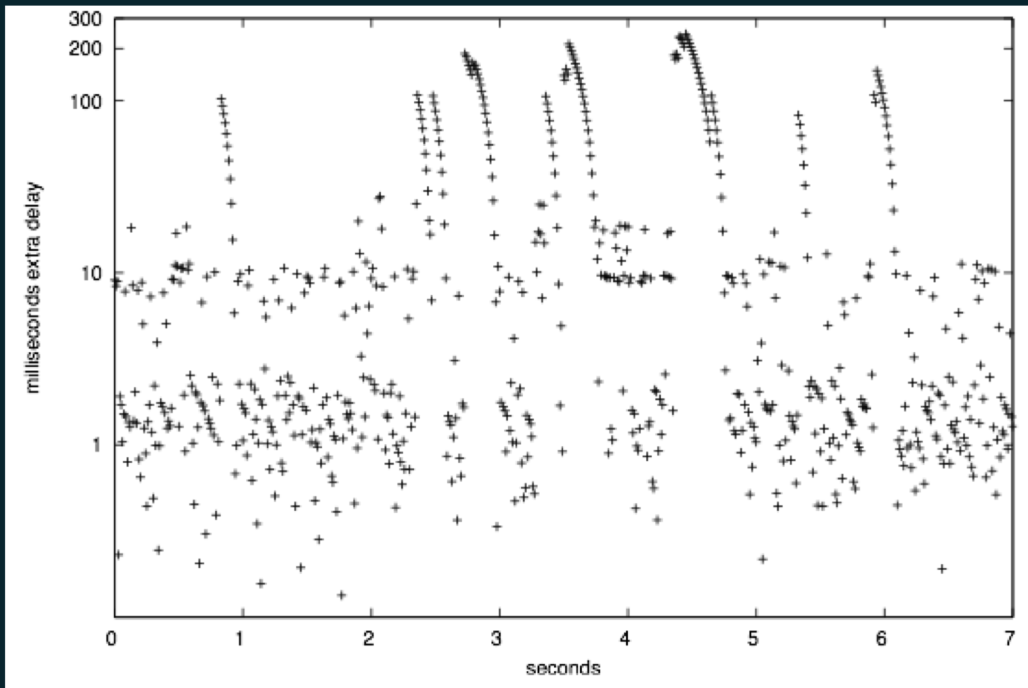
Data from measurements and simulations

July 28, 2012

Goals

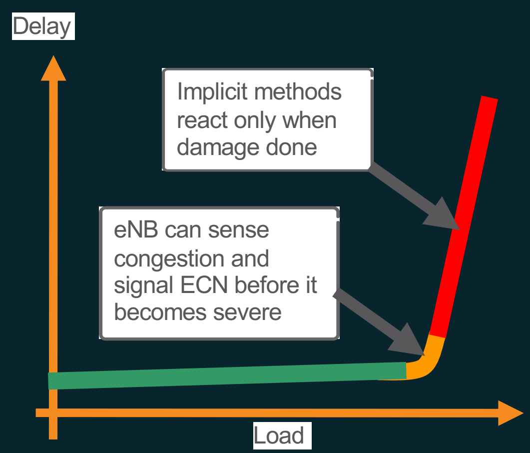
- Goal of this session is too have a discussion where we learn about the relevant data to help us understand the problem and design solutions
- Want to increase understanding of topics like:
  - Latency we see on networks
  - Impact waiting for congestion to happen on latency
  - What happens when TCP competes with Voice/Video
  - Impact on retransmissions vs forward error correction

LTE Latency – Paper 28

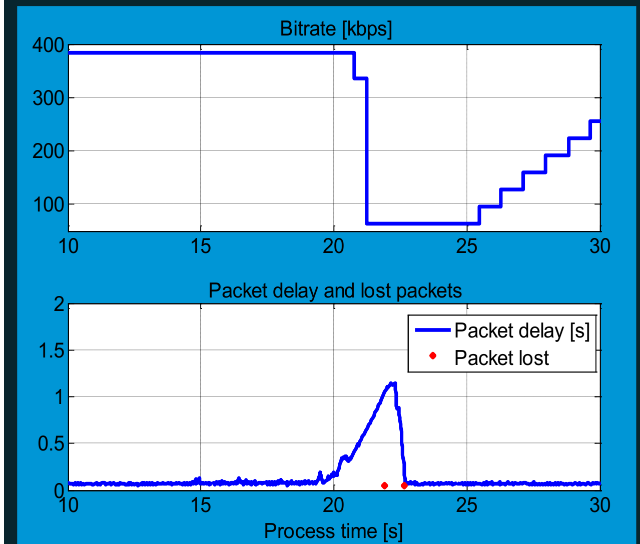


- Commercial LTE networks have:
  - Near-infinite queue (no losses until >5 seconds)
  - Poisson-distributed packet arrivals
  - Quickly-varying link speed
  - Highly long-tailed delays (RTCP jitter estimate is bad)
- Operators do not (yet) believe this.
- Open question: How much throughput would transport forfeit if it wanted to cap queue at 100 ms?

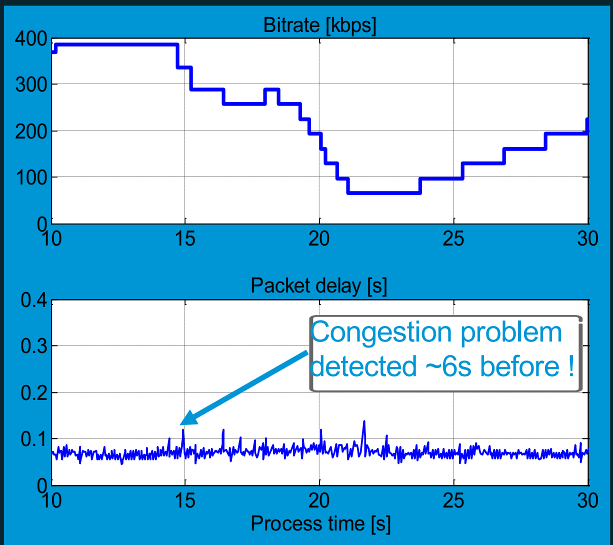
Impact of ECN - Paper 4



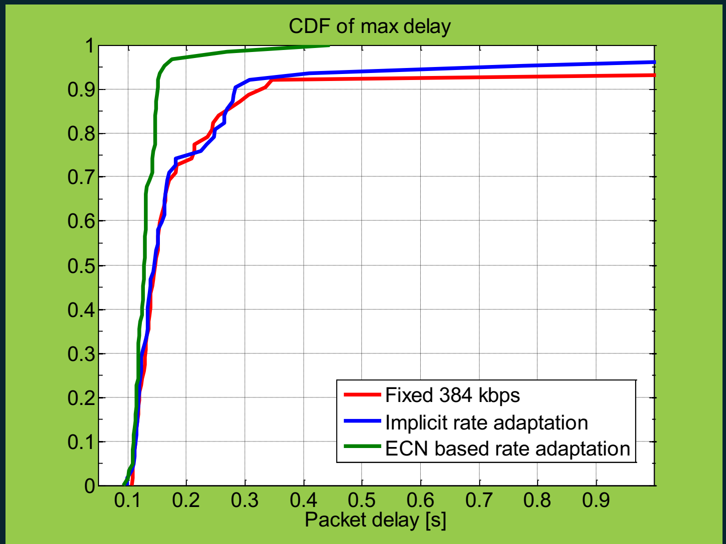
- Simulation of ECN on LTE shows
  - significantly less packet loss
  - initiating the rate adaptation in advance of actual congestion
  - better sharing the cost of congestion
  - a very significant reduction in latency
  - better quality for all users



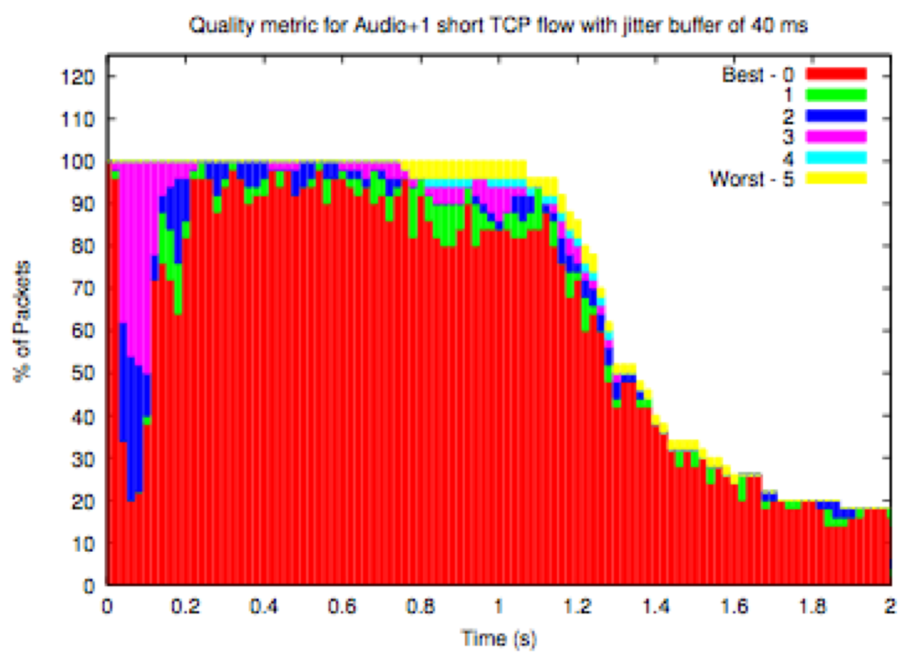
Implicit method



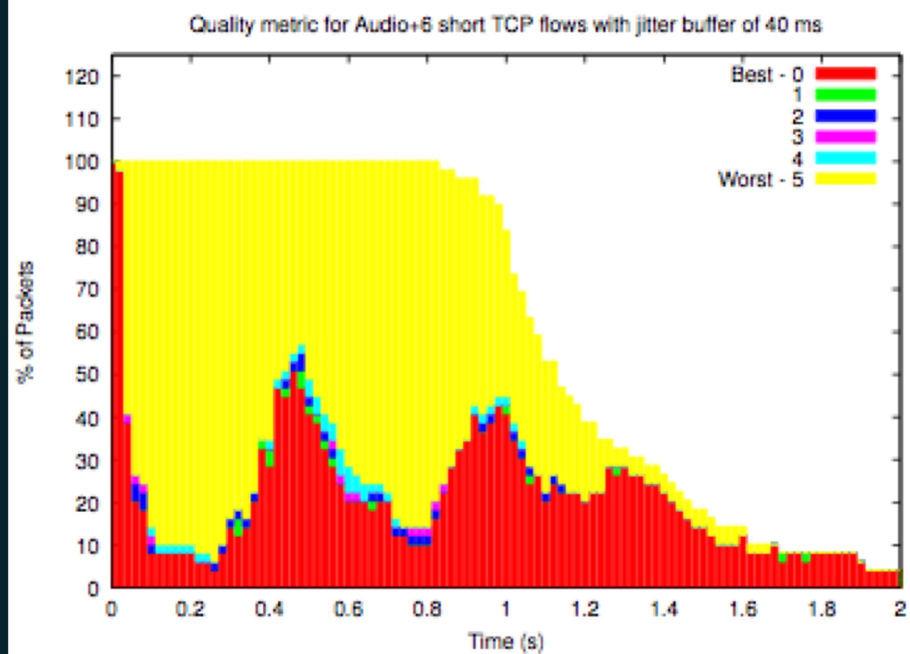
Explicit (ECN) method



Impact of TCP– Paper 9



(a) With one concurrent TCP flow, 50 replications



(b) With six concurrent TCP flows, 50 replications

- Single short TCP flow impacts voice on startup but six short TCP flows destroy voice quality on high speed cellular network (2 mbps)
- Drops are due to the jitter, not losses

Can we be TFRC style fair ? – Paper 25

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

- What bandwidth would be safe relative to 1 TCP connection?

Can we be TFRC style fair ? – Paper 25

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

RTT(ms) \ Loss(%)	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

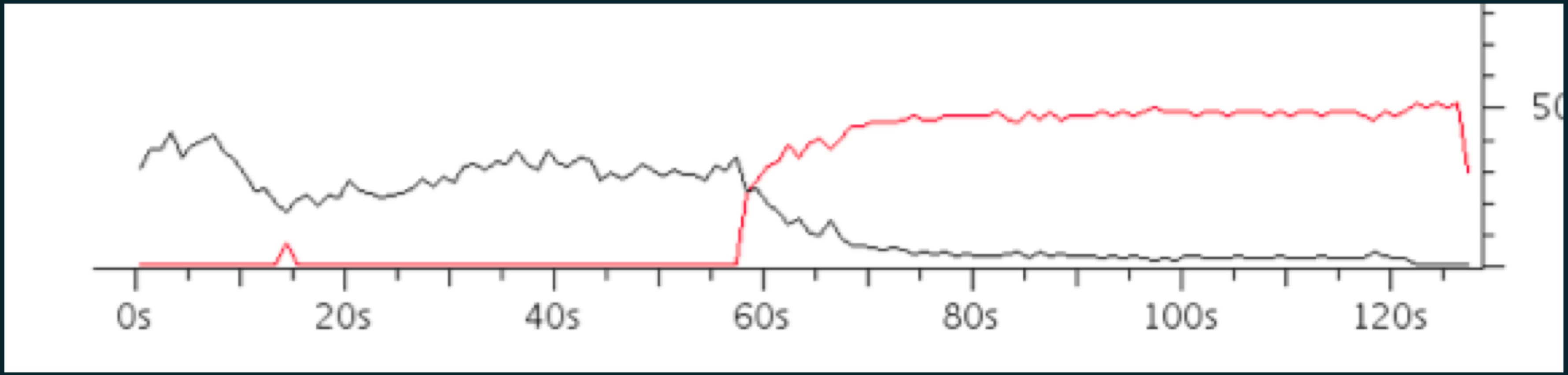
Video Quality Color Code:

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

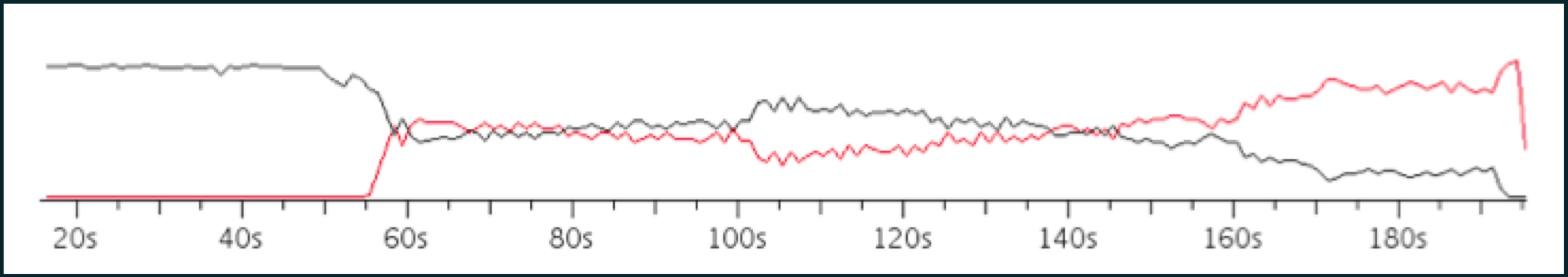
- What bandwidth would be safe relative to 4 TCP connection?

Video vs TCP– Paper 11

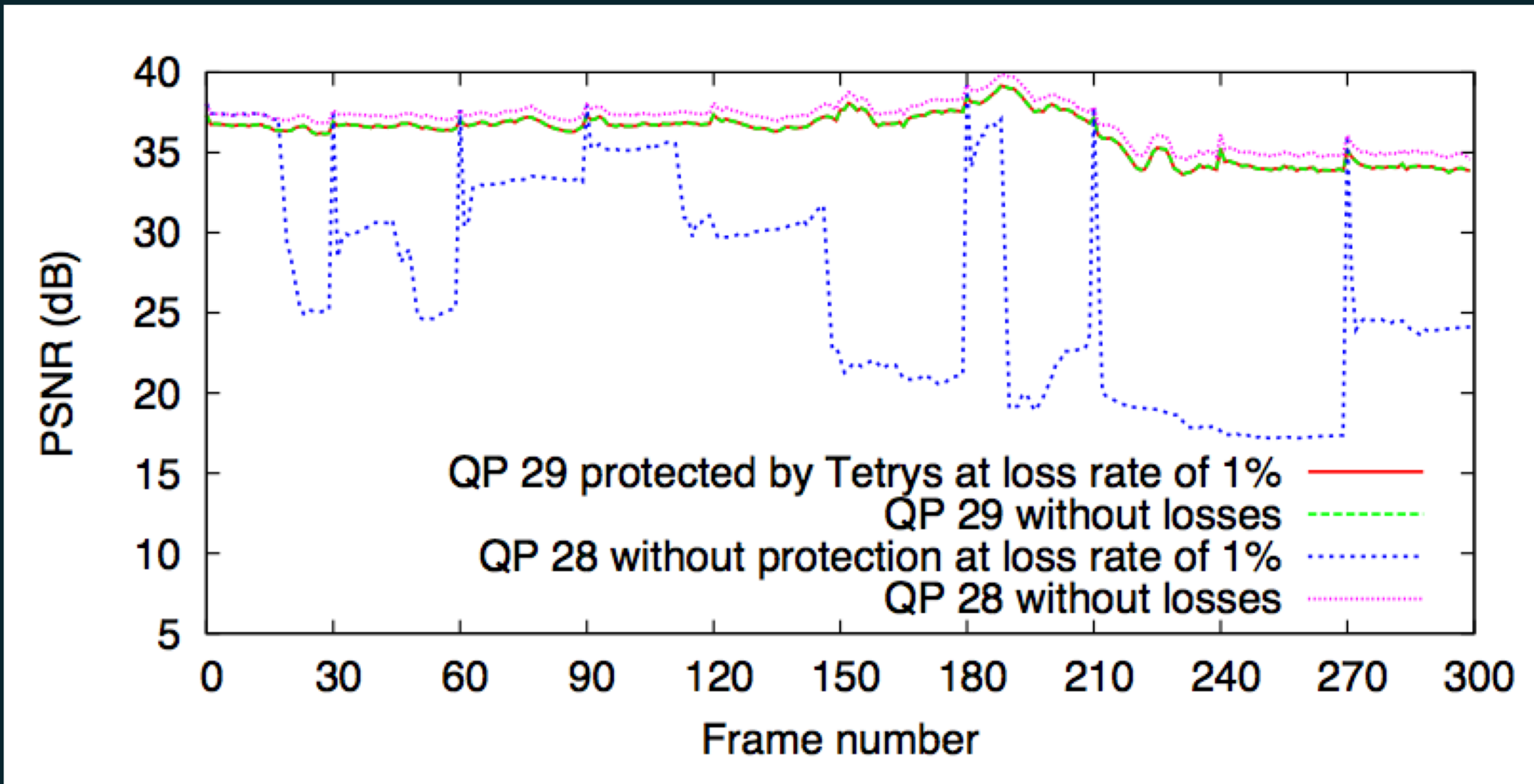
- Not so fair …



- Adaption takes time …

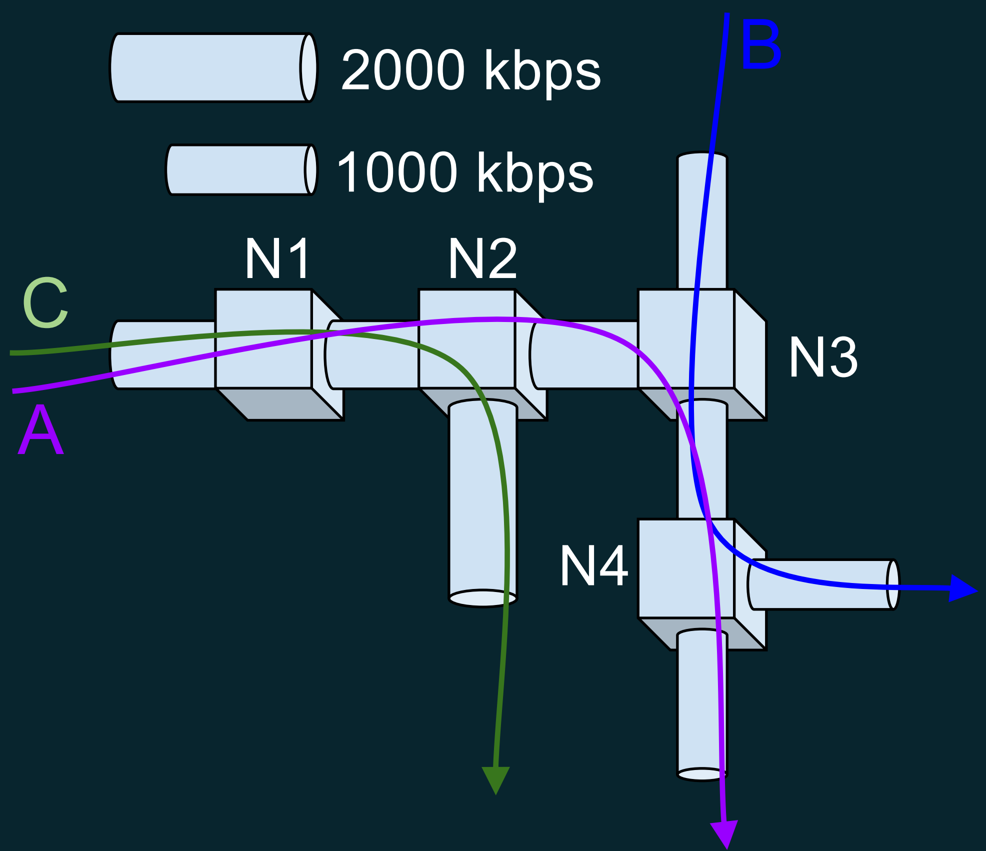


Forward Error Correction – Paper 30



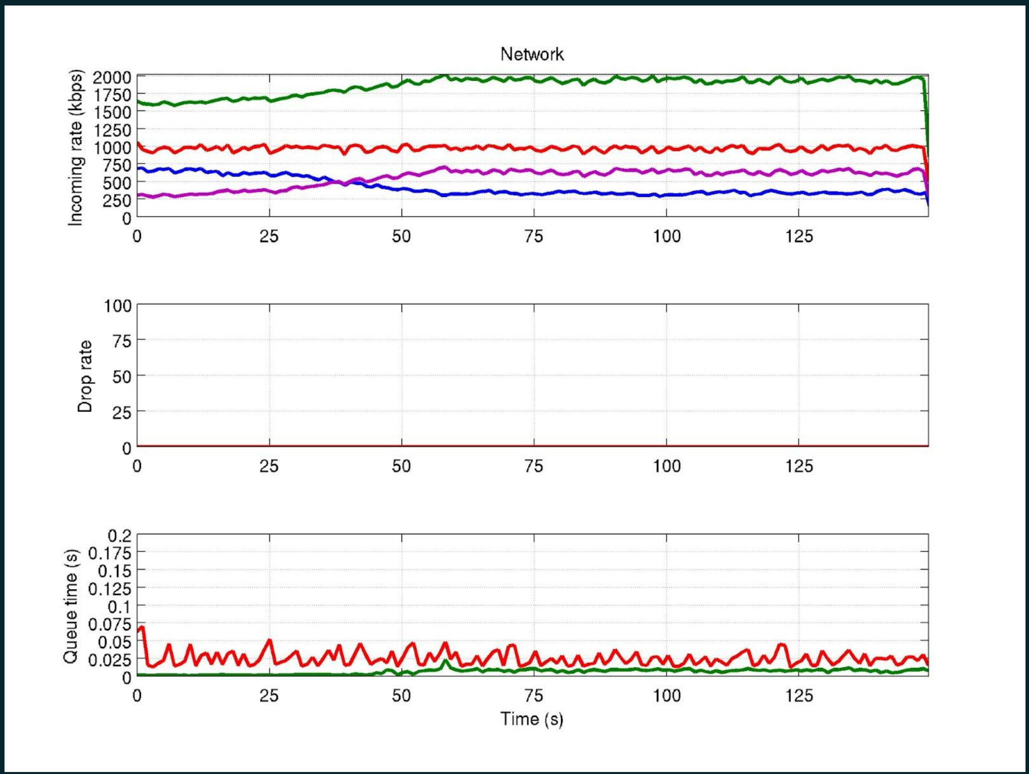
- Better to user experience with lower bit rate + fec
- Better latency than ARQ based schemes

RRTCC Simulations – Paper 6
Self-fairness - Problems



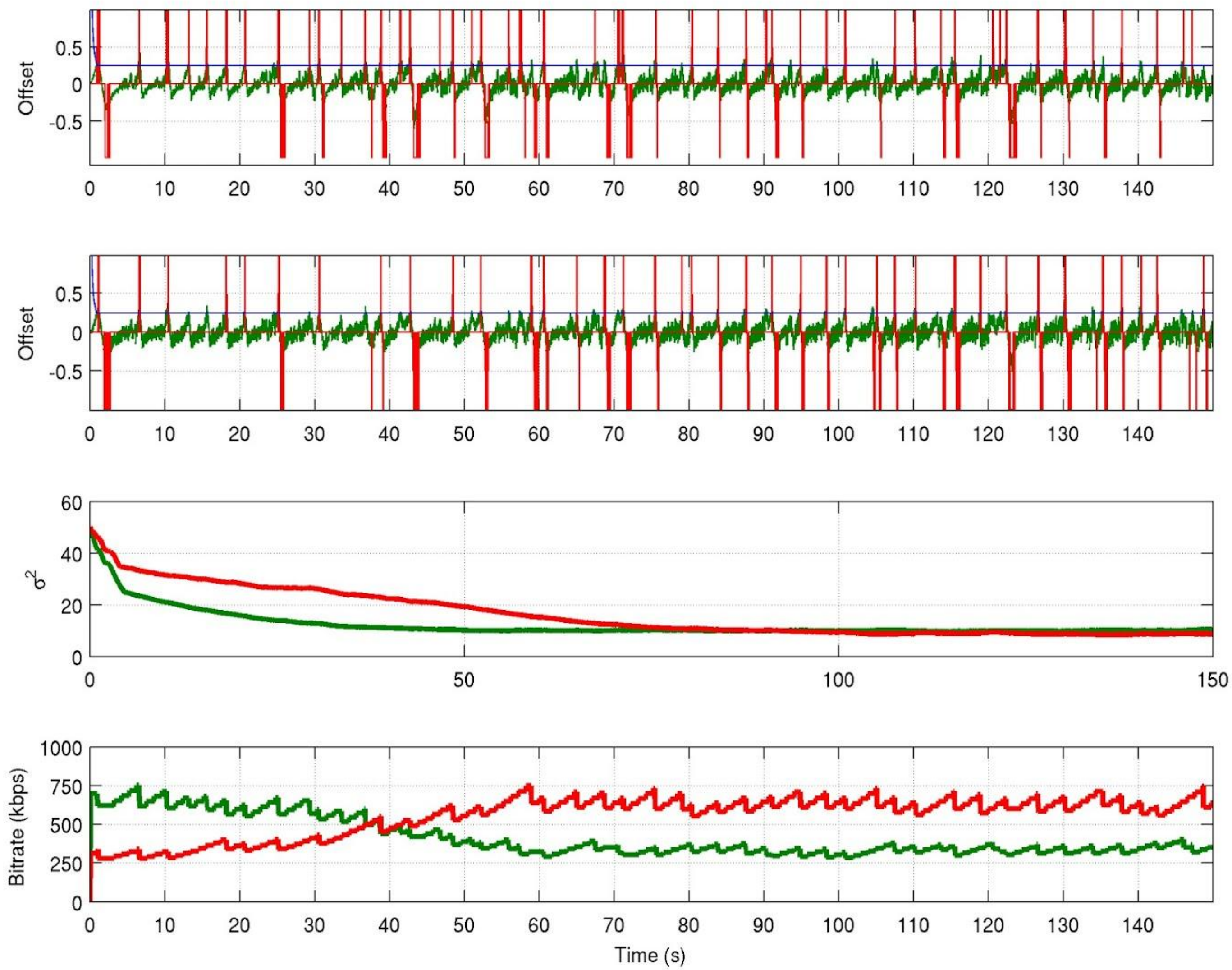
- Flow A and B are controlled by RRTCC.
- Flow C is constant at 1.3 Mbps.
- Flow A is "noisier" than B due to C.
- We expect that flow A and B will share the 1 Mbps bottleneck fairly, i.e., 500 kbps each.

Self-fairness - Problems

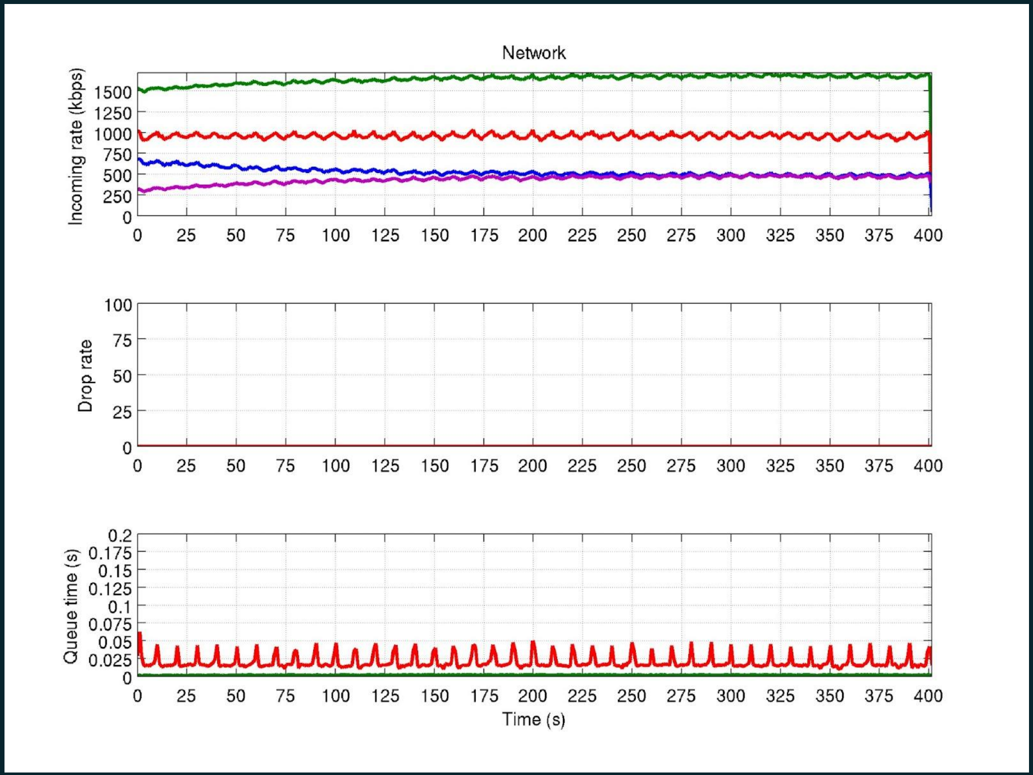


- Different amount of cross traffic.
  - Flow A is more noisy than B due to significant cross traffic at N1.
  - Noisier signal means more filtering and slower detection.
  - Flow B loses against flow A.
- Other problems: Self-aware burstiness.

Under the Hood



Self-fairness - Possible solution



- Fixed noise variance.
- Additive Increase, Multiplicative Decrease.
- Send-side smoothing.