

# **Keeping ahead of the Telcos**

## **Sending Audio over IP**

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# Why did the BBC start this?

- BBC Local Radio Stations share live programme material
- Results weren't quite as expected
- Commenced testing in 3<sup>rd</sup> Qtr 2004
- Restarted ~1 year later
- Like buses, they all come at once!



# Migration to IP – why?

- Cheaper solutions possible on IP – more cost effective than ISDN
- IP allows management
- IP greater problems than ISDN – hence performance testing of products
- Survey by N/ACIP (Audio Contribution over IP)
- Possible loss of ISDN - not upgraded

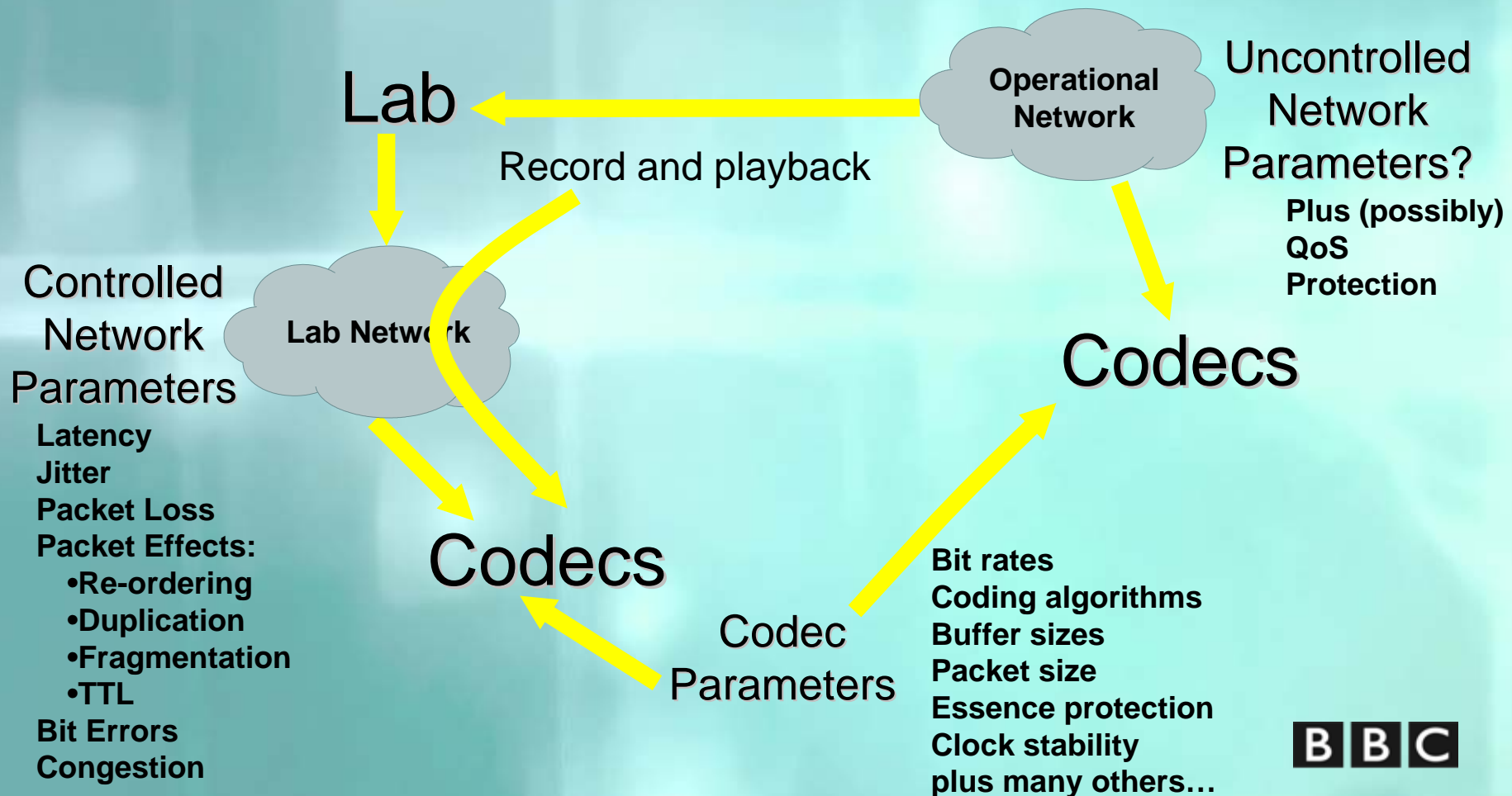


# The Tools

- Powerful, but expensive network emulation and network loading – some free
- Allow individual adjustment of network parameters in isolation (or together)
- Recording live network conditions (and playback)
- Measurement tools – both commercial and free

# Lab based or real networks?

**BOTH!**

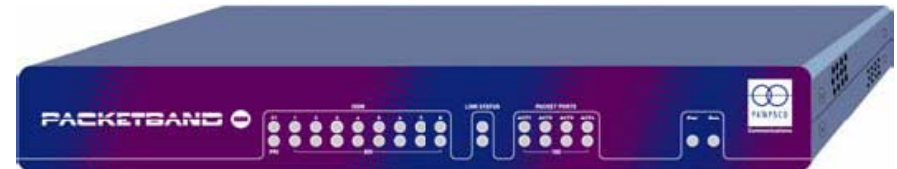
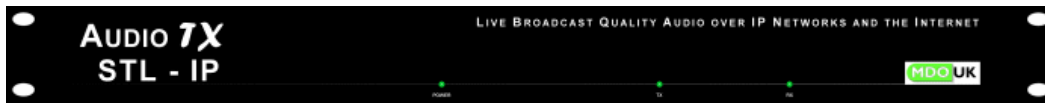




# Other considerations...

- Test equipment doing what you think?
- Audio Quality
- Comparison of codecs
- Protection
- Many different products

# Audio over IP Products

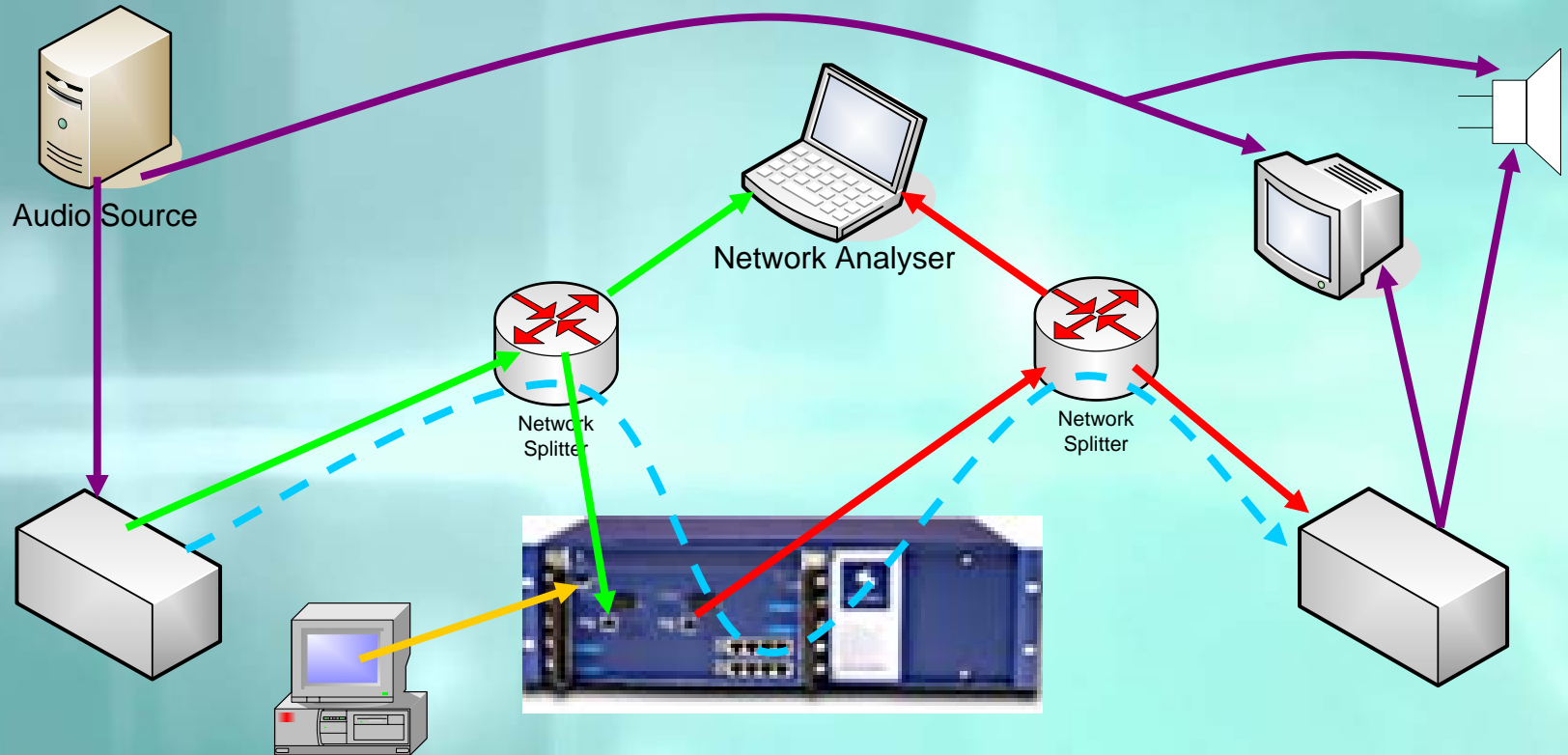


Plus others...





# General Test Arrangement





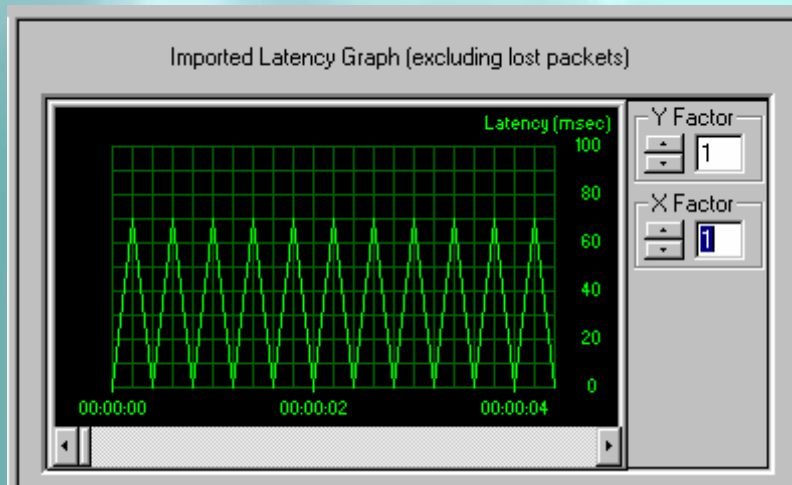


# Results Presentation

- Correlation of network conditions and audio disruptions?
- Profiles?
- Tables of products – yes/no on network types?
- What's best?

# Example Profiles for Jitter

Latency Change or Jitter (ms)	50	60	70	80	90	100	200	300
Interval (ms)	Jitter/Interval or Rate of Change of Jitter							
10	5.00	6.00	7.00	8.00	9.00	10.00	20.00	30.00
20	2.50	3.00	3.50	4.00	4.50	5.00	10.00	15.00
30	1.67	2.00	2.33	2.67	3.00	3.33	6.67	10.00
40	1.25	1.50	1.75	2.00	2.25	2.50	5.00	7.50
50	1.00	1.20	1.40	1.60	1.80	2.00	4.00	6.00
60	0.83	1.00	1.17	1.33	1.50	1.67	3.33	5.00
70	0.71	0.86	1.00	1.14	1.29	1.43	2.86	4.29
80	0.63	0.75	0.88	1.00	1.13	1.25	2.50	3.75
90	0.56	0.67	0.78	0.89	1.00	1.11	2.22	3.33
100	0.50	0.60	0.70	0.80	0.90	1.00	2.00	3.00
110	0.45	0.55	0.64	0.73	0.82	0.91	1.82	2.73
120	0.42	0.50	0.58	0.67	0.75	0.83	1.67	2.50
130	0.38	0.46	0.54	0.62	0.69	0.77	1.54	2.31
140	0.36	0.43	0.50	0.57	0.64	0.71	1.43	2.14
150	0.33	0.40	0.47	0.53	0.60	0.67	1.33	2.00
160	0.31	0.38	0.44	0.50	0.56	0.63	1.25	1.88
170	0.29	0.35	0.41	0.47	0.53	0.59	1.18	1.76
180	0.28	0.33	0.39	0.44	0.50	0.56	1.11	1.67
190	0.26	0.32	0.37	0.42	0.47	0.53	1.05	1.58
200	0.25	0.30	0.35	0.40	0.45	0.50	1.00	1.50
250	0.20	0.24	0.28	0.32	0.36	0.40	0.80	1.20
300	0.17	0.20	0.23	0.27	0.30	0.33	0.67	1.00
400	0.13	0.15	0.18	0.20	0.23	0.25	0.50	0.75
500	0.10	0.12	0.14	0.16	0.18	0.20	0.40	0.60
600	0.08	0.10	0.12	0.13	0.15	0.17	0.33	0.50
700	0.07	0.09	0.10	0.11	0.13	0.14	0.29	0.43
800	0.06	0.08	0.09	0.10	0.11	0.13	0.25	0.38
900	0.06	0.07	0.08	0.09	0.10	0.11	0.22	0.33
1000	0.05	0.06	0.07	0.08	0.09	0.10	0.20	0.30
1100	0.05	0.05	0.06	0.07	0.08	0.09	0.18	0.27
1200	0.04	0.05	0.06	0.07	0.08	0.08	0.17	0.25
1300	0.04	0.05	0.05	0.06	0.07	0.08	0.15	0.23
1400	0.04	0.04	0.05	0.06	0.06	0.07	0.14	0.21



0 to 70ms latency  
for 200ms interval

# Increasing RX Buffer Size

Latency Change or Jitter (ms)	50	50	60	60	70	70	80	80	90	90	100	100	200	200	300	300
Audio Delay Buffer size (ms)	0	100	0	100	0	100	0	100	0	100	0	100	0	100	0	100
Interval (ms)	Jitter/Interval or Rate of Change of Jitter															
10	5.00	5.00	6.00	6.00	7.00	7.00	8.00	8.00	9.00	9.00	10.00	10.00	20.00	20.00	30.00	30.00
20	2.50	2.50	3.00	3.00	3.50	3.50	4.00	4.00	4.50	4.50	5.00	5.00	10.00	10.00	15.00	15.00
30	1.67	1.67	2.00	2.00	2.33	2.33	2.67	2.67	3.00	3.00	3.33	3.33	6.67	6.67	10.00	10.00
40	1.25	1.25	1.50	1.50	1.75	1.75	2.00	2.00	2.25	2.25	2.50	2.50	5.00	5.00	7.50	7.50
50	1.00	1.00	1.20	1.20	1.40	1.40	1.60	1.60	1.80	1.80	2.00	2.00	4.00	4.00	6.00	6.00
60	0.83	0.83	1.00	1.00	1.17	1.17	1.33	1.33	1.50	1.50	1.67	1.67	3.33	3.33	5.00	5.00
70	0.71	0.71	0.86	0.86	1.00	1.00	1.14	1.14	1.29	1.29	1.43	1.43	2.86	2.86	4.29	4.29
80	0.63	0.63	0.75	0.75	0.88	0.88	1.00	1.00	1.13	1.13	1.25	1.25	2.50	2.50	3.75	3.75
90	0.56	0.56	0.67	0.67	0.78	0.78	0.89	0.89	1.00	1.00	1.11	1.11	2.22	2.22	3.33	3.33
100	0.50	0.50	0.60	0.60	0.70	0.70	0.80	0.80	0.90	0.90	1.00	1.00	2.00	2.00	3.00	3.00
110	0.45	0.45	0.55	0.55	0.64	0.64	0.73	0.73	0.82	0.82	0.91	0.91	1.82	1.82	2.73	2.73
120	0.42	0.42	0.50	0.50	0.58	0.58	0.67	0.67	0.75	0.75	0.83	0.83	1.67	1.67	2.50	2.50
130	0.38	0.38	0.46	0.46	0.54	0.54	0.62	0.62	0.69	0.69	0.77	0.77	1.54	1.54	2.31	2.31
140	0.36	0.36	0.43	0.43	0.50	0.50	0.57	0.57	0.64	0.64	0.71	0.71	1.43	1.43	2.14	2.14
150	0.33	0.33	0.40	0.40	0.47	0.47	0.53	0.53	0.60	0.60	0.67	0.67	1.33	1.33	2.00	2.00
160	0.31	0.31	0.38	0.38	0.44	0.44	0.50	0.50	0.56	0.56	0.63	0.63	1.25	1.25	1.88	1.88
170	0.29	0.29	0.35	0.35	0.41	0.41	0.47	0.47	0.53	0.53	0.59	0.59	1.18	1.18	1.76	1.76
180	0.28	0.28	0.33	0.33	0.39	0.39	0.44	0.44	0.50	0.50	0.56	0.56	1.11	1.11	1.67	1.67
190	0.26	0.26	0.32	0.32	0.37	0.37	0.42	0.42	0.47	0.47	0.53	0.53	1.05	1.05	1.58	1.58
200	0.25	0.25	0.30	0.30	0.35	0.35	0.40	0.40	0.45	0.45	0.50	0.50	1.00	1.00	1.50	1.50
250	0.20	0.20	0.24	0.24	0.28	0.28	0.32	0.32	0.36	0.36	0.40	0.40	0.80	0.80	1.20	1.20
300	0.17	0.17	0.20	0.20	0.23	0.23	0.27	0.27	0.30	0.30	0.33	0.33	0.67	0.67	1.00	1.00
400	0.13	0.13	0.15	0.15	0.18	0.18	0.20	0.20	0.23	0.23	0.25	0.25	0.50	0.50	0.75	0.75
500	0.10	0.10	0.12	0.12	0.14	0.14	0.16	0.16	0.18	0.18	0.20	0.20	0.40	0.40	0.60	0.60
600	0.08	0.08	0.10	0.10	0.12	0.12	0.13	0.13	0.15	0.15	0.17	0.17	0.33	0.33	0.50	0.50
700	0.07	0.07	0.09	0.09	0.10	0.10	0.11	0.11	0.13	0.13	0.14	0.14	0.29	0.29	0.43	0.43
800	0.06	0.06	0.08	0.08	0.09	0.09	0.10	0.10	0.11	0.11	0.13	0.13	0.25	0.25	0.38	0.38
900	0.06	0.06	0.07	0.07	0.08	0.08	0.09	0.09	0.10	0.10	0.11	0.11	0.22	0.22	0.33	0.33
1000	0.05	0.05	0.06	0.06	0.07	0.07	0.08	0.08	0.09	0.09	0.10	0.10	0.20	0.20	0.30	0.30
1100	0.05	0.05	0.05	0.05	0.06	0.06	0.07	0.07	0.08	0.08	0.09	0.09	0.18	0.18	0.27	0.27
1200	0.04	0.04	0.05	0.05	0.06	0.06	0.07	0.07	0.08	0.08	0.08	0.08	0.17	0.17	0.25	0.25
1300	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.07	0.07	0.08	0.08	0.15	0.15	0.23	0.23
1400	0.04	0.04	0.04	0.04	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.14	0.14	0.21	0.21

Audio Delay  
Range (ms)

48-95

Max 144  
usually  
less

48-110

144 - 158  
usually  
less

48-115

144-220

48-130

144-230

48-140

144-240

48-150

144-250

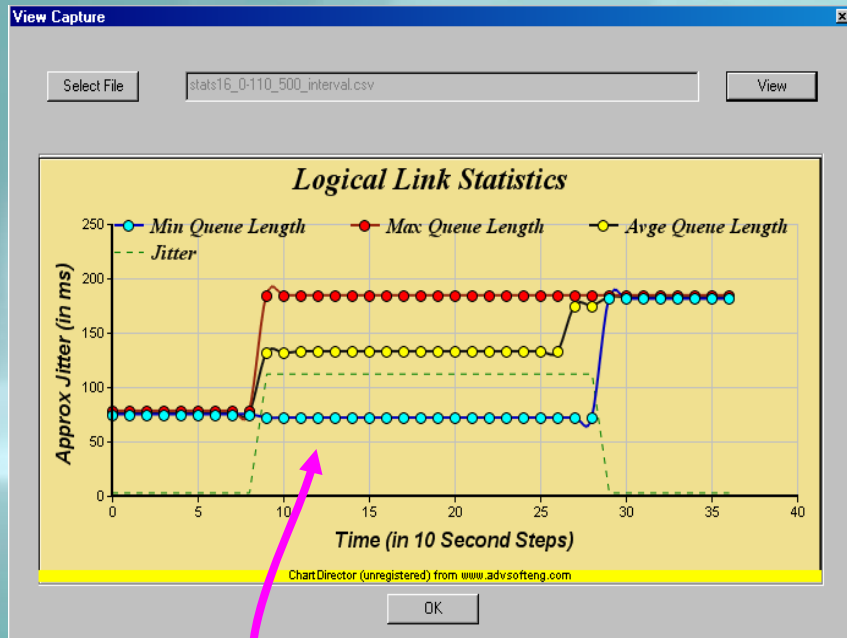
48-250

144-350

48-350

144-450

# Example Jitter test



Disrupted then ok after 7 secs

Jitter (ms)	Interval (ms)	Queue Length		Measured Jitter (ms)	Comments
		Min	Max		
100	100	28	61	103	Initial Hiccup for ~10 secs, then ok
150	100	17	56	121	Initial Hiccup for ~4 secs, then ok
200	100	2	45	134	pulsing effect for first 15 secs, then ok
250	100	14	60	143	Dead for first 8 secs, then ok
300	100	11	60	153	brief squeak, dead for first 8 secs, then ok
350	100	0	51	156	brief squeak, dead for first 8 secs, then ok
400	100	0	51	159	Dead for first 8 secs, pulse for 3 secs, then ok
450	100	0	53	165	Dead for first 8 secs, pulse for 3 secs, then ok
500	100	11	64	165	Pulsing for first 14 secs, then ok
800	100	7	63	175	Pulse for first 7 or 8 secs, then ok - Queue length didn't return to the previous values, were at 4(min) & 5(max)
1000	100	4	63	184	Disrupted, then ok after 18 secs
1500	100	3	64	190	Disrupted, then ok after 14 secs
2000	100	3	64	190	Searching', framed after 14 secs, then ok
2500	100	0	62	193	Disrupted, then ok after 10 secs
3000	100	2	63	190	Disrupted, then ok after 10 secs

50	500	8	25	53	No discernable effects
100	500	0	33	103	No discernable effects
110	500	23	59	134	Disrupted, then ok after 7 secs
120	500	0	39	121	Brief squeak, then ok
130	500	0	43	134	Hard squeak & pulse for first 8 secs, then ok
140	500	0	46	143	Squeak and pulse for first 8 secs, then ok
150	500	15	64	153	Pulsing for first 14 secs, then ok
200	500	0	64	200	Continuous disruption/pulsing/popping for 2 mins plus
250	500	No consistent values could be recorded			Continuous disruption/pulsing/popping for 25 seconds, followed by 'searching'/framed. Repeated cycle until stopped.



# Future Possibilities

- Speed up lab based testing
- Automate longer term tests over network
- Detection of audio disruptions
- Masks for tests/products
- Scenarios required by BBC
- ITU-T Recommendation G.1050 Model
- Simulation software based on this model



# Summary

- Migration to IP inevitable
- Testing essential
- Profiling of products and networks

## Light at the End of the Tunnel?

- Many improvements coming with audio over IP
- Standards being considered by the N/ACIP EBU Group for interoperability of products in collaboration with manufacturers & others

Thank you for your time and  
attention

Any Questions?