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December 15, 1994

Norm O'Doherty
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Jetset Centre
5 Queens Road, Melbourne, 3004

Report on Telecom Australia's Service Verification Tests (G.001)

Dear Norm

Please find attached my report on Telecom Australia's Service Verification Tests in accordance with consultancy agreement specified under contract number 2060.

Should you require any further information or assistance please do not hesitate to call me at the above number.

Yours sincerely

Michael Rumsewicz

Report on Telecom Australia's Service Verification Tests (G.001)

Michael P. Rumsewicz

Executive Summary

This report is provided in response to AUSTEL's request for external assistance in reviewing the engineering, methodological and statistical issues arising from Telecom Australia's Service Verification Tests (as documented in General Information Paper G.001, Service Verification Tests for Telecom's PSTN, Reference [1]).

Quoting from G.001, the service verification tests have been developed:

"... as the basis upon which a telephone service at the Service Delivery Point may be considered to be operating satisfactorily at the time the tests were conducted."

The report focuses upon four areas as specified in the consultant's brief (Attachment 1):

- Reasonableness of national targets for call connection and call continuity / call dropout and how these are impacted by network modernisation.
- Reasonableness of performance targets for individual customers and how these are impacted by variations in network equipment type / generation and time of day traffic variations.
- Statistical validity of individual verification tests based upon test call sampling
- The acceptability of Telecom Australia's General Information Paper G.001 describing the tests.

The main findings of this analysis are:

- Telecom Australia's national targets for call connection are more stringent than internationally accepted guidelines (E.721).
- Telecom Australia does not appear to have a documented national call continuity / call dropout target (no specific reference is provided in G.001). It is recommended that such targets be developed in order to more comprehensively monitor customer grade of service.

- The individual customer performance targets employed by Telecom Australia appear to be reasonable given the current stage of network evolution. Tightening of these targets may be appropriate as network modernisation nears completion.
- Customer calling profiles (which provide the basis of the Service Verification Test test calling pattern) would be more accurately determined through the use, for instance, of Tekelec / CCS 7 equipment or, in the case of 008 / 1800 subscribers, customer billing records. The actual technique employed (including customer consultation as presently performed), however, should be determined on a case by case basis dependent upon technology, timeliness and resource constraints, with the additional proviso that customer confidence in the test be assured.
- The service verification tests performed by Telecom provide sufficient information to quantify, to a reasonable degree of accuracy, the call connection performance of the network. However, the statistical test being applied to the data is inconsistent with the goals of the testing as stated in Telecom's Customer Fault Management Process (000 841, Section 5.4.6) and AUSTEL's report, The COT Cases (April, 1994).

  An alternative statistical test, using the same data, is proposed in this report. We note that the alternative statistical test would also have been passed when applied to the data obtained in service verification tests performed to date.
- The General Information Paper G.001 overall provides an adequate and easy to understand description of service verification tests.

Beyond the scope of the consultancy brief, we also make the following observations:

- Service Verification Tests may at some stage need to be designed for other services (for instance, ISDN and mobile).
- In a multi-service deliverer environment it may be necessary to have an independent set of generic tests (endorsed by AUSTEL) to address difficult network faults in an equitable fashion across all service deliverers.
- In a multi-service deliverer environment, calls will be originated in a number of different networks to difficult network fault customers. In compiling testing profiles to mimic customer calling patterns, it may be necessary to send test calls through a variety of service deliverer's networks. Safeguards would need to be in place to protect the interests of the various parties with respect to information collected in such a fashion.

1. INTRODUCTION

This report is provided in response to AUSTEL's request for external assistance in reviewing the engineering, methodological and statistical issues arising from Telecom Australia's Service Verification Tests (as documented in General Information Paper G.001, Service Verification Tests for Telecom's PSTN).

Quoting from G.001, the service verification tests have been developed:

> *"... as the basis upon which a telephone service at the Service Delivery Point may be considered to be operating satisfactorily at the time the tests were conducted."*

The report focuses upon four areas as specified in the consultant's brief (Attachment 1):

- Reasonableness of national targets for call connection and call continuity / call drop-out and how these are impacted by network modernisation.
- Reasonableness of performance targets for individual customers and how these are impacted by variations in network equipment type / generation and time of day traffic variations.
- Statistical validity of individual verification tests based upon test call sampling.
- The acceptability of Telecom Australia's General Information Paper G.001 describing the tests.

The analysis provided herein is based upon documentation provided by AUSTEL and Telecom Australia, interviews with Telecom Australia personnel and public information resources.

This report is structured as follows:

- Section 2: Examination of issues directly related to the consultancy brief.
- Section 3: Other comments arising from the analysis but beyond the scope of the consultancy brief.
- There are also a number of Appendices and Attachments, including a copy of the consultancy brief and the author's *curriculum vitae.*

2. Analysis and discussion arising from the consultancy brief

2.1 National Performance Targets

"The reasonableness of national targets for call completion and call continuity / call drop-out and how these are impacted by network modernisation"

The Public Switched Telephone Services (PSTS) Tariff (Amended July 1994) states that the Telecom Australia prescribed national average levels of call failures due to network loss are:

- 1.5% for local calls (daily average), and
- 2.6% for STD day rate.

The primary international benchmarks for comparison with these targets are to be found in International Telecommunication Union - Telecommunication Sector (ITU-T, formerly known as CCITT) recommendations. Recommendation E.721 (Network Grade of Service Parameters and Target Values in the Evolving ISDN, 1991, Reference [3]) provides the following target values:

- 2% for local calls
- 3% for toll (long distance) calls.

Telecom Australia's targets are within these standards.

We note that these benchmarks apply to fully digital networks employing Signalling System Number 7, a stage that has not yet been reached in Telecom Australia's network.

We believe that Telecom Australia's present national call delivery targets are reasonable for the current stage of network evolution.

As Telecom Australia's network modernisation program continues (as prescribed under the Future Mode of Operations and subsequently accelerated) it can be expected that the actual call delivery performance levels achieved will naturally improve. Such improvements stem from improvements in switching technology (most digital exchanges are now either non-blocking or almost non-blocking with respect to internal switching connections), fewer exchanges in the end-to-end call path and lower costs for transmission bandwidth for circuit switched services. It is likely that congestion on circuit groups, in a fully digital network, will be almost the sole cause of non-delivery of a call (outside of equipment failure). As a result, customer expectations for call delivery may also increase as improved service levels become the norm. Tightening of target grade of service levels may be appropriate in the future.

Providing a detailed analysis and recommendations for long term target grade of service levels is beyond the scope of the consultancy brief, although we note that market forces in a competitive environment may automatically shape future targets (for example, service quality is often used in advertising in the USA to differentiate the service provided by various long distance carriers).

In the above mentioned Tariff filing, no comment is made concerning call continuity / call dropout objectives.

ITU-T Recommendations E.428 (Call Retention, 1992, Reference [2]) and Q.543 Section 2.5.1.1 (Digital Exchange Performance Design Objectives, Reference [4]) provide guidance as to accepted international norms on call continuity / call dropout. E.428 states that in the intermediate term, the cut-off call ratio for subscriber to subscriber calls, measured over a 24 hour period, should be less than 0.5% for five minute calls. In any time consistent hour, the call cut-off rate may not exceed 3% (we assume this applies to five minute calls also).

Moreover, Recommendation Q.543 states that for 64 kb/s switched connections, the probability of premature release of an established connection, in any one minute interval, should be less than 0.002%. For two and five minute calls, this would translate to (approximately), call dropout probabilities of 0.004% and 0.01% respectively. We recognize that this applies to ISDN exchanges (rather than networks as a whole), but it clearly indicates the quality of service expected in mature digital networks and hence should be considered as potential longer term targets.

On a network level, such stringent dropout criteria would give rise to targets of approximately 0.008% for local calls (assuming less than five exchanges are used in a local call) and 0.016% for long distance calls (assuming a maximum of eight exchanges in such calls).

It is important to note that these dropout rates refer only to switch related causes and do not take into account the possibility of transmission facility failure (for example, due to high error rates or cable cuts). Such factors would also need to be considered in the final specification of call continuity grade of service targets.

On the national level, Telecom Australia appears to have no precise criteria for call continuity / call dropout and hence it is recommended that such criteria be developed or that international standards be adopted.

2.2 Individual Performance Targets

"The reasonableness of performance targets for individual customers for call connection and call continuity / call dropout and how these may be impacted by variations in network equipment type / generation and time of day traffic variations."

The ITU-T objectives described in the previous section refer to entire network averages, that is, an "all exchanges to all exchanges" (or multipoint to multipoint) description of objectives for service quality. No breakdowns into point to point, point to multipoint, or multipoint to point objectives are provided.

Also, AUSTEL has recently released a Draft Technical Standard for Comment on "End-to-End Network Performance" (Reference [6]). That document addresses overall network average performance, measured over monthly periods. As the measurement period consists of the full 24 hour day, including mass call-ins and special tariff discounts, service standards established there are not relevant to the service verification tests, which specifically exclude such situations and are aimed at multipoint to point service issues. As such, we will not be referring to the AUSTEL End-to-End Network Performance draft again in the following.

Certain national jurisdictions and service deliverers have, however, identified local levels at which action or notification of regulatory.of bodies should occur.

For example, the Swedish Telecommunications Administration (STA) sets network wide call accessibility targets of 98% and 97% for whole day and busy time (defined as the ten most traffic intensive hours of the day) respectively (Reference [5]). In addition to this, they also set corresponding targets for individual traffic cases (exchange rather than network based) of 96% and 94% respectively, regardless of equipment type. We note here that call accessibility implies that calls are connected and speech is possible.

Also, these are 1991 targets and relate to the Swedish network as it existed then. Some of the targets used at that time were under review for tightening as a result of network modernization.

Similarly, the Florida Public Service Commission provided a benchmark (in 1991) of 90% call completion for calls originating at any exchange. While somewhat less than that set by the STA, the question of guaranteeing certain levels of service all subscribers is specifically addressed.

As implied in the STA reference cited above, specific attention must be given to time of day considerations in the formulation of grade of service objectives. Clearly, call blocking on circuit groups is most likely to occur during the daily busy periods, which may vary from locale to locale. For instance, exchanges in the central business district are likely to experience peaks during the morning and afternoon while regional exchanges may see peaks in the evenings.

As part of the Service Verification Test procedure, information is compiled from the customer to determine a profile of incoming call attempts, by time of day and originating exchange. Note, however, that periods of mass calling and special discount tariff are precluded from the test regime. Thus, a "fair" reflection of the customer's incoming grade of service would appear to be provided by the Service Verification tests.

As different customers will have different busy periods, determining a single benchmark across all possible load profiles is difficult. However, the STA benchmarks of 96% and 94% for all day and busy time set an appropriate "best practice" standard. The use of a 95% objective, independent of equipment type, by Telecom Australia is directly in line with this practice.

As discussed in Section 2.1, network modernisation will almost naturally result in improved call delivery performance as a result of the internally non-blocking design of digital exchanges. Combined with the simpler process of adding circuit capacity in such exchanges, customers are likely to see improved service quality as the FMO proceeds and it may be necessary, in order to maintain such standards, to further tightens the call delivery targets specified as part of the Service Verification Tests. Determining specific targets for fully digital networks is beyond the scope of this consultancy.

We believe that the individual performance target for call delivery established by Telecom Australia for the Service Verification tests is a reasonable target for the current stage of network evolution. In the future, when Telecom's Australia's network becomes fully digital, it may be appropriate to further tighten these targets.

The STA call delivery standard cited above requires that calls not only be delivered, but also have acceptable sound quality and are not dropped. Thus, the 96% / 94% individual targets cited apply overall to blocking, speech quality and call retention, but no specific breakdown is provided.

With regard to call continuity / call dropout, Telecom's stated objective of 98% call continuity is a significantly less stringent criterion than Recommendation E.428 (0.5% for five minute calls), especially as it applies only to two minute calls, although we note that E.428 applies to digital networks rather than analogue.

Given the present stage of network evolution, in itself Telecom Australia's call continuity target of 98% appears to be reasonable. However, when combined with the 95%

call delivery target, this could lead to unnecessarily looser standards. A combined standard, along the Swedish lines, allowing for a minimum 95% call delivery with acceptable speech quality and call retention, and a minimum 98% call retention may be more appropriate. In addition, as network digitization nears completion, a more stringent call retention criterion, along the lines of E.428, may be appropriate.

2.3 Statistical Validity of Testing Procedure

"The statistical validity of individual verification tests based upon call sampling and the adequacy and format of the test data collection."

This section of the brief pertains primarily to those tests described in Section 6.3, Public Network Call Delivery Tests of G.001. There are a number of issues to be covered in assessing the statistical validity of the testing described in Section 6.3.1 of G.001. In the following we shall raise the issues and discuss them in a narrative fashion. Similar discussion applies to testing described in Section 6.3.2 of G.001, so only differences will be noted at the end of the section to avoid needless repetition.

Are the test calls representative of calls being sent to the customer?

As part of the test procedure, Telecom consults with the customer in order to determine typical call profiles, busy and minimal traffic periods and incoming call distributions. Test calls are then generated according to this profile in order to mimic calls destined for the customer.

An alternative, and more accurate, technique to determine incoming call patterns that could be employed (with the cost of extra time in data collection) would be through the use of Signaling System 7 monitoring equipment (such as the Tekelec / CCS 7 monitoring tool or similar). Incoming call setup messaging to the host exchange destined for the customer could be trapped to allow for traffic distribution analysis. Collection of this data may take some time (many days to weeks) depending on the call volumes destined for the customer.

In the case of customers subscribing to 008 / 1800 service, detailed billing records are available which could be analyzed to determine, with a similar degree of precision, the incoming call distribution.

Note that these two alternative techniques would also allow accurate profiling on a day of week basis, allowing the test call pattern to be set up similarly. This would eliminate any potential concerns on traffic day of week variations affecting the "representativeness" of the test call pattern.

We believe that more accurate incoming customer call profiles could be created through use of Tekelec / CCS7 equipment or, in the case of 008 / 1800 customers, use of billing records. The actual technique employed (including customer consultation as presently performed), however, should be determined on a case by case basis dependent upon technology, timeliness and resource constraints, with the additional proviso that customer confidence in the test be assured.

Are sufficient calls being generated to collect a statistically valid sample?

Document G.001 recommends that at least 500 test calls be made. Samples of this size are sufficient to determine, with a reasonable degree of precision, the call delivery performance to the customer.

The document G.001 states that tests 6.3.1 (success rate of incoming calls), 6.3.2 (call continuity) and 6.3.3 (ring test) may be combined, that is, the test calls made can be used for the analysis of all three tests simultaneously. However, the procedure described in 6.3.1 requires that only the first 500 test calls be used. Test 6.3.2 requires 500 successful calls be made and thus more calls than test 6.3.1 are required. By restricting the data analysis in 6.3.1 to only the first 500 calls, incongruous situations may arise, as noted in discussions with Cliff Mathieson.

We believe that sufficient data is being collected to provide a statistically valid sample. In addition, the entire dataset should be analyzed for verifying that service standards are being met, rather than artificial limits of 500 calls.

Is sufficiently detailed data being collected to analyze the test results?

Telecom Australia has provided all call delivery data collected in the Service Verification Tests performed to date. The data includes, for every test call - time and date - originating number and exchange - terminating number and exchange - call disposition (for example, connected and blocked in network). Data in such detail allows the comprehensive analysis of ineffective call attempts, in particular, the ability to determine whether there are correlations in the ineffective calls, such as:

- time of day
- originating exchange
- type of call failure.

We believe that the data being collected is sufficiently detailed to allow a comprehensive analysis of ineffective attempts.

Are the statistical tests being performed appropriate to the question being asked?

The nature of the statistical test that should be applied to the data depends greatly on the information desired from the data. Telecom Australia, in its Customer Fault Management Procedure - Overview (draft dated 15 July, 1994) states in Section 5.4.6 (Verification Tests):

> "The purpose of verification tests is to demonstrate that the service provided to a specific SDP [Service Delivery Point] is satisfactory and meets published standards."

In addition, quoting directly from the AUSTEL COT Cases report,

> "Telecom, in consultation with AUSTEL, develop by May 1, 1994 -
>
> - a standard of service against which Telecom's performance may effectively be measured
>
> - a relevant service quality verification test."

These statements clearly indicate that the Verification Tests need to determine the actual call delivery performance to the customer.

Telecom Australia, as part of document G.001, applies a standard technique based on hypothesis testing. Hypothesis testing is used to determine whether there is sufficient evidence to reject one hypothesis (known as the null hypothesis) in favour of another (known as the alternative hypothesis). If insufficient evidence exists to reject the null hypothesis, the null hypothesis is accepted. It is critical to note that this is not the same as saying that the null hypothesis has been verified.

> *In the context of the Service Verification Tests, this means that the test applied checks to see whether it can be "proved" beyond reasonable level of doubt that less than 95% of calls to the customer are delivered, as opposed to showing that at least 95% are delivered.*

The standard being applied by Telecom in its proposed analysis of the data is that if the overall (population) call delivery performance is greater than 95% (the individual customer target), then there is only a 2.5% chance (the reasonable level of doubt mentioned in the previous paragraph) that the sampled data will fall below their stated benchmark (465 calls out of 500). In statistical parlance, this would be called a Type I error and reflects the chance that you will incorrectly reject the null hypothesis.

To verify that the performance meets published standards, the actual call delivery performance needs to be determined. A more appropriate analysis of the data would be to determine the overall probability that the call delivery performance is better than 95% (the individual customer benchmark), and provide (as a benchmark) a lower limit on this probability.

Such a test would be conducted as follows:

1. From the data, determine the number of successful call attempts (denote this by k in the following) out of the total number of call attempts (call this n).
2. Compute p = k/n.

   The variable p is the estimate of the call delivery performance obtained from the data.
3. Compute z = (p - 0.95) / sqrt (p * (1 - p) / n)
4. The probability that the overall call delivery performance is at least 95% is given by inverting a normal distribution on (0,1). This is simpler than it sounds because, for instance, Microsoft Excel provides the function NORMSDIST(z) which does exactly this.
5. If NORMSDIST(z) > 0.9, then say that the call delivery performance standards have been met. This would mean that there is a 90% chance that more than 95% calls are delivered to the customer, based on the test data.

Depending on the degree of confidence required to pass the test, 0.9 can be replaced by a more suitable benchmark. Examples of the use of this test are provided in Appendix A.

We note here that performing the above statistical test is identical to switching the null hypothesis prescribed by Telecom Australia to one which assumes that the call delivery performance is less than 95%, and then seeking sufficient evidence to show that the performance is actually higher than 95% (the new alternative hypothesis).

In other words, Telecom Australia should be provide convincing evidence that their call delivery performance meets their specified target, rather than seeking convincing evidence that their call delivery performance fails to meet their target.

There are a number of important points worth noting here:

- Application of such a test places the onus on the service deliverer to demonstrate that their targets are being met rather than on the customer to show that the performance targets are not being met.
- Using the test Telecom proposes is likely to lead to the dissatisfaction of customers if they are shown test statistics in the 93% to 95% range (which would pass Telecom Australia's criteria). For public relations reasons the test we propose may be more suitable.
- For comparison, if 500 test calls are made, the Telecom Australia pass criteria is that 465 calls be successfully delivered, whereas our proposed test would require

that 481 calls be successfully delivered.

- The higher benchmark needed to pass the test proposed here does not change the stated call delivery target of 95%. It merely provides a different pass / fail criterion for the test of whether 95% call delivery is being achieved.
- Application of our proposed method on actual customer data provided by Telecom Australia to AUSTEL on Service Verification Tests performed to date would still have resulted in all tests passing satisfactorily.

With regard to testing described in Section 6.3.2 of G.001 (Call Continuity / Dropouts to Neighbouring LIC), an essentially identical discussion applies except for modification of the pass criteria due to the higher standard expected in call continuity (less than 2% of calls dropping out). In this case, references to 95% or 0.95 in the above are replaced by 98% or 0.98 as appropriate.

We believe that, given the stated purpose of the Service Verification Tests supplied in the Telecom Australia Customer Fault Management Procedures document (000 841) and that of the AUSTEL COT cases report, the statistical test being applied to the collected data is inappropriate. We believe the alternative test described above is more suitable and, in addition, promotes customer confidence in the test procedure and analysis.

Can anything else be learned from the test data, especially if the test fails?

As described in document G.001, the only statistical test applied to the data collected in Tests 6.3.1 and 6.3.2 is a "macro" test, that is, only the total number of failed calls and attempted calls is examined. No further analysis of the data, for example by originating exchange, is performed to determine whether there are any patterns to the way in which calls fail during the test. As mentioned earlier, the data collected is quite comprehensive and easily allows for such analysis. Furthermore, the use of Microsoft Excel easily facilitates such analysis.

In Appendix B we provide portions of such an analysis we have performed on the collected data.

Moreover, in instances in which the test fails to meet the pass criteria, such investigations may provide sufficient information to track down specific network or test equipment related problems which, upon rectification, may not require the entire test to be re-run, merely, that connected with affected portions of the network / test setup. This could result in significant time and cost savings.

We believe that the analysis of collected data should be expanded to include an examination of call failures broken down by originating exchange, time of day and type of failure. In the event that correlations in the failures are found, fur-

ther investigations, as appropriate, should be undertaken.

2.4 Acceptability of Telecom Australia Document G.001

"The acceptability of Telecom's explanatory document "Service Verification Tests for Telecom's PSTN" as a user friendly and accurate description of the test purpose and regime".

We believe that the document is, overall, well-written and provides an adequate and simple description of the test procedure and data analysis. However, the discussion of demonstration tests (including pass / fail criteria) appears out of place in this document and should be removed altogether.

Some further minor changes, as noted below, would help to clarify the document.

Section 1: (a) The purpose of the testing is to determine whether satisfactory service is being delivered to a customer at the time the tests are performed. These tests serve as an integral part of Telecom Australia's Customer Fault Management Procedures, an on-going process. References to Coopers and Lybrand's "Review of Telecom Australia's Difficult Network Fault Policies and Procedures" and AUSTEL's "The COT Cases" report confuse the issue as to the purpose of the tests. For example, the reader may wonder whether the tests are to applied only as part of COT case resolution. This paragraph could be removed without loss of information to the reader.

(b) Presumably Paragraphs 4 and 5 will be removed when the document becomes stable.

Section 2:

This section states that the demonstrations described in Section 7 are not part of the verification test procedure. As such, Section 7, together with this reference should be removed from the document as its presence can be confusing to readers not familiar with the overall details of testing and data analysis.

Sections 3, 4 and 5: No comment.

Section 6: (a) If the target audience for this document includes customers whose service needs to be tested, the test details provided in Section 6.1 are overly in-depth for the average reader. We suggest a simple description of what the test is attempting to verify would be more appropriate in this case. For example, 6.1.2 could be replaced by something in the spirit of:

"A test will be performed to ensure that there is sufficient voltage applied to an incoming line to ring three phones when an incoming call arrives".

Details of the tests would be documented in the Service Verification Test Work Instructions or similar.

(b) Section 6.3 is reasonably clearly written although, as noted earlier, the test cases are not truly independent. Obviously the text will need to be modified if changes are made to the analysis of the data in accordance with recommendations made earlier.

(c) For the Ring Test (Section 6.3.3) some indication of what is considered a significant sample of test calls should be given.

Section 7: As mentioned earlier, we believe this section should be removed from the document. If it is not, the subsections marked "Desired Outcome" should be removed as the intent of the demonstration cannot be to verify the call delivery performance to the customer given the sample size. Such "Desired Outcomes" are confusing and, potentially, misleading to the customer (in terms of either too many calls failing or reading too much into cases in which all calls succeed).

3. COMMENTS OUTSIDE SCOPE OF CONSULTANCY BRIEF

This section provides discussion / findings arising from investigations associated with the consultancy, but outside the normal scope of the brief.

3.1 Service Verification Tests for Other Services

As specifically stated in document G.001, the service verification tests are to employed only as a test of "... operation of a fixed terrestrial analogue voice ring-in / loop out connection within Telecom's own Public Switched Telephone Network and connected to a standard exchange either directly or via a Pair Gain System." It is conceivable that the equivalent of difficult network faults may arise in the context of other services, for example, ISDN, high speed packet or mobile services. Service Verification Tests do not exist for such services at this time. In addition, the current set of tests focus on incoming calls to the customer line; tests for outgoing problems may also be necessary.

In terms of Customer Fault Management Procedures, it may be worth investigating the proactive creation and standardization of tests covering difficult network faults for services such as ISDN or mobile.

The experience gained through the creation of tests associated with G.001 could be exploited to put in place a comprehensive plan in advance of any potential difficult network faults for other services.

3.2 Service Verification Tests for Other Network / Service Deliverers

Telecom Australia is clearly the author and owner of the tests / testing procedures associated with the Service Verification Tests. Just as other services may require similar procedures to be put in place, other network / service deliverers may also require procedures such as these for dealing with difficult network faults. It would appear inappropriate if Telecom Australia's intellectual property in this area were simply made public domain. The independent creation of such a set of tests may necessary to provide an equitable solution.

In terms of dispute resolution, it may be worth investigating whether AUSTEL needs to play a role as author of a set of generic tests for service verification which can be applied to all network / service deliverers. Such tests may need to be created for a variety of services (such as ISDN or mobile).

The creation of such tests would allow for uniform standards to be applied across the industry rather than in a piecemeal fashion to individual deliverers. It would also be a proactive step in handling potential future disputes.

3.3 Multiple Service Deliverer Environments

The service verification tests described in G.001 focus on incoming calls to the affected Telecom Australia customers. Such calls can, of course, be originated from people or businesses subscribing to other service deliverers, in particular Optus at the current time.

In the near future it may occur that 20% of long distance service between Sydney and Melbourne will be carried by Optus, with the rest carried, in the main, by Telecom Australia. The compilation of customer calling profiles is then complicated by the fact that the called party (the complaining customer) is probably unaware of the service deliverers used by their callers. To mimic the level of service perceived by the customer, it would then be necessary to send calls through both the Telecom Australia *and* Optus networks. As more service deliverers enter the arena, such considerations become even more complex.

It is important to note that this would then create situations in which testing regimes effectively provide a measure of delivered service of each network through which test calls are sent. Such information would may be proprietary and hence safeguards would need to be in place to protect the interests of the various participants. This could include, for instance, the employment of independent testing and data analysis facilities.

It may be worth investigating whether service verification test calls should be originated in each service deliverers network, terminating on (or near) the difficult network fault customers line. Such investigations should include, but not be limited to, provisions that may have to be made for allowing test calls to be sent through another service deliverer's network.

We note that there is some synergy here with the suggestion that AUSTEL investigate the need for an independently created, generic set of verification tests that can be applied across all service deliverers.

REFERENCES

[1] Telecom Australia, G.001, *Service Verification Tests for Telecom's PSTN*, Issue Interim 27th September, 1994.

[2] CCITT Recommendation E.428, *Connection Retention*, 10/92

[3] CCITT Recommendation E.721, *Network Grade of Service Parameters and Target Values for Circuit-Switched Services in the Evolving ISDN*, 1991

[4] ITU-T Recommendation Q.543, *Digital Exchange Performance Objectives*, 3/93.

[5] Swedish Telecommunications Administration, *Accessibility and quality on the national network, 1st quarter of 1991.*

[6] AUSTEL, *End-to-End Network Performance*, Draft Technical Standard for Comment, December 5, 1994.

APPENDIX A: Example application of proposed alternative statistical test

Suppose 500 test calls are made. As stated in Telecom Australia's General Information Paper, the pass criteria for their statistical test is that at least 465 (93%) of call attempts be successfully delivered.

Suppose 470 calls are successfully delivered. Thus, the test passes the Telecom Australia's test criteria.

For the alternative test proposed,

Step 1: k = 470, n = 500.

Step 2: p = k / n = 470 / 500 = 0.94

Step 3: z = (p - 0.95) / sqrt (p * (1 - p) / n) = (0.94 - 0.95) / sqrt (0.94 * (1-0.94) / 500)

= -0.01 / sqrt (0.0001128) = -0.01 / 0.01062 = -0.9416

Step 4: NORMSDIST(-0.9416) = 0.1736. Thus, the probability that the call delivery performance exceeds 95% is about 17%.

Step 5: If we wish to be 90% sure that the call delivery performance is better than 95%, the test fails (because 0.1736 is less than 0.9).

Suppose, instead, that 485 calls are successfully delivered. Then

Step 1: k = 485, n = 500.

Step 2: p = k / n = 485 / 500 = 0.97

Step 3: z = (p - 0.95) / sqrt (p * (1 - p) / n) = (0.97 - 0.95) / sqrt (0.97 * (1-0.97) / 500)

= 0.02 / sqrt (0.0000582) = 0.02 / 0.007629 = 2.622

Step 4: NORMSDIST(2.622) = 0.9956. Thus, the probability that the call delivery performance exceeds 95% is about 99.56%.

Step 5: If we wish to be 90% sure that the call delivery performance is better than 95%, the test passes (because 0.9956 is greater than 0.9).

APPENDIX B: Detailed Analysis of Telecom Australia Service Verification Test Data

At AUSTEL's request, Telstra has provided the raw data on call delivery performance from the Service Verification Tests performed to date. Table 1 provides a breakdown of the failed calls according to cause code for each customer. Calls failing due to problems with test equipment have been removed from the data set. The code NWL represents network congestion, and WNO represents that an undefined tone was detected and is registered as a failed call attempt. Data in cases in which the customer had two lines tested are shown by # / #.

Table 1: Call failures broken down by cause code (Line 1 / Line 2)

Customer	NWL	WNO	Total calls
Bova	1		1161
Dawson	1 / 0	0 / 1	626 / 502
Love	2		522
Main	1	3	508
Smith	0 / 1		608 / 617 ←
Trzcionka	3		1046
Turner	0 / 3 (A)	0 / 1	531 / 532

Breaking down the data in this fashion allows us to see whether there are common causes for the call failures. In addition, we examined the data to determine the originating nodes for the failed calls.

The marked entry is of interest when analyzed in this fashion as all three NWL calls originated at the BATMAN 2 exchange from a total of 92 generated there. While such a result might be expected from any one exchange (that is, one case of approximately 3% congestion), had, for instance, 10 more calls failed at BATMAN 2 the overall statistical pass /fail criteria would still have been passed and no further investigation taken place. This would be the case even though, in this hypothetical example, 14% of calls from BATMAN 2 had failed.

While some unusual results might be expected given the statistical nature of the testing, more detailed analysis should be performed to determine whether or not such situations occur. In the event that they do occur, further testing should be performed to determine whether the observations are truly random in nature or are caused by some underlying fault in either the originating exchange, connecting network or test equipment during that phase of testing.

APPENDIX B: Consultant's *curriculum vitae*

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Educational Background: Ph.D. in Applied Mathematics from the University of Adelaide (1989)

EMPLOYMENT EXPERIENCE

July 1994 - Present **CITRI**, Carlton, Victoria

Senior Research Fellow

RESEARCH AREAS

Overload control and performance of Advanced Intelligent Networks and Signalling System Number 7.

Performance analysis of the proposed Telecommunications Information Networking Architecture.

July 1988 - June 1994 **Bell Communications Research**, Red Bank, NJ.

Member of Network Services Performance and Control group

SIGNALING SYSTEM NUMBER 7 (SS7)

Member of the team formed to analyze the cause of the SS7 Common Channel Signaling Network (CCSN) outages in California and Washington, D.C. in June/July, 1991. Specifically, performed design analysis of equipment involved and determined root cause of failures and mechanism by which the failure spread to other points in the network. Design change recommendations were made and subsequently implemented and demonstrated to significantly improve system and network robustness.

Member of the team formed after the outages that studied the contributions of SS7 protocol and network element standards to the problems that arose.

Introduced the concept of examining service completion rather than message throughput in the analysis of SS7 CCSNs, in the presence of application recovery procedures and realistic customer behavior. This analysis demonstrated that message throughput can be an extremely misleading measure of service (from the subscriber point of view) and illustrated the need for feedback flow control mechanisms during periods of Signalling Transfer Point (STP) processor (as opposed to link) overload.

Performed technical analysis of STP products, including both theoretical studies and testing. This involved analysis of software design algorithms for message processing, processing of network management traffic, overload controls, performance and capacity.

TELSTRA SERVICE DATABASE PLATFORM

Member of the team hired by Telstra (April - June 1994) to analyze the design of the Service DataBase (SDB) One3 platform. Specific responsibilities in the areas of system robustness and performance, including making recommendations on network controls that would improve the reliability of the service during periods of congestion.

ADVANCED INTELLIGENT NETWORK (AIN)

Identified performance issues in providing AIN, including switch and signaling network capacity impacts, delay constraints, overload control (from both the switch and signaling network viewpoints) and grade of service objectives.

Analyzed the switch capacity impact of providing a variety of AIN services.

Identified performance issues in which multiple services compete for the same network resources. These concerns highlight the need for well defined congestion control objectives so that essential services may be protected while maintaining good service levels for lower priority traffic.

PERSONAL COMMUNICATIONS SERVICES (PCS)

Identified performance issues in providing PCS, including switch and signaling network capacity impacts, delay constraints, overload control (from both the switch and signaling network viewpoints) and grade of service objectives.

Analyzed the switch capacity impact of providing PCS service for a specific switching system, demonstrating the extremely high processing cost of a PCS call relative to non-PCS calls. This work led directly to the inclusion of alternative architectures in Bellcore's Network and Operations Plan that limit the switch capacity impact of providing PCS.

CIRCUIT SWITCHING SYSTEMS

Analyzed the performance of various circuit switching systems. This included capacity estimation, delay performance modeling and overload control effectiveness. The work required a variety of approaches, from field testing, to mathematical modeling to simulation.

Developed models to study the effects of new service offerings on circuit switch capacity, taking into account customer characteristics.

MISCELLANEOUS

Analyzed the performance, capacity and overload characteristics of voice messaging systems. Identified problem areas in design and recommended appropriate changes which were subsequently incorporated into the systems.

Developed algorithms for determining operator team sizes when directory assistance and toll services are combined under various operating regimes. Involved in the implementation of these algorithms for use by field personnel.