# *Avaya Communication Manager*
# *Software Based Platforms*

## High Availability Solutions

## Avaya Servers and Media Gateways

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**Avaya Servers and Media Gateways**

***Driven With*** **Avaya Communication Manager Software**

## Executive Summary

Globally based Companies are staking their ongoing success on their use of reliable communications systems. With the convergence of voice and data applications running on common systems, the stakes of ensuring any time anywhere communication has grown higher. A communications failure could bring an entire business to a halt, with disastrous consequences. Executives and communication managers who understand what it takes to assure "high availability" will be well positioned to choose vendors who can deliver systems their enterprise can count on under a wide variety of potential conditions.

Availability is a measure of "uptime," that is the percentage of time a system is performing its useful function. In voice systems, availability calculations are based on the presence of traditional "dial-tone," plus the ability of the user to make and receive calls in a desired manner. This is also true for associated applications like contact centers.

Traditionally, "real-time" applications such as voice communications have demanded higher availability than applications based on "store and forward" technology. The concept of "delay" differs in voice engineering from data engineering in large part due to human factors and end user expectations As a result of this demand, the availability of soundly designed voice systems has an historic track record of 99.95% - 99.9999%. This equates to a down-time range of about four (4) hours per year on the low end of the range of availability, to 32 seconds per year on the high end. In fact, this historical track record is the source of the oft-mentioned benchmark of reliability: "five (5) nines".

The measure of success for traditional "store and forward" applications was not as dependent on continued availability. As long as information got to its intended destination by the time it was needed, success was achieved. It did not matter whether the process required re-transmission of packets, or if packets experienced a temporary delay because of bandwidth optimization or other reasons. As a result of this historic difference in measure of success, systems designed for store and forward applications have not had (nor did they necessarily need) a track record of 99.999% availability. In more recent years, in recognition of growing customer expectations as cost of providing bandwidth has dropped, vendors of these systems have developed ways of improving availability. Examples include server "clustering" and providing the option of redundancy for potentially critical sub-assemblies, such as power supplies, tape drives, and processing elements.

Converged infrastructures must adequately support both types of applications into the future. Real-time needs still exist and must be supported well, side by side with the store and forward applications carried over packet-based transport systems of the past.

In Avaya Communication Manager with its supporting Avaya Server and Media Gateway product lines, Avaya has developed solutions with the strategic historical strengths of:

- applications designed to run at 99.999% availability,
  - supported by underlying service infrastructures that operate at 99.999% availability or better ,
    - which run on a variety of transport architectures
      - like circuit switching designed to operate at over 99.9999% availability,
      - or packet (cell) architectures like ATM, which can run at 99.99% to 99.999% availability.

Over the decade, Avaya has introduced robust support of Internet protocol (IP)-based transport. Because the building-block architecture is cleanly implemented in the three (3) layers just listed, flexibility in transport (including mix and match) is supported. This integration results in no compromise to the wide array of applications Avaya provides at the top layer. Applications like contact centers and multi-national networking work smoothly, with the same look and feel, regardless of the underlying transport systems. As a result, enterprises can evolve toward converged infrastructures at the rate that makes sense for their business.

Avaya employs a variety of techniques to achieve this high reliability at each level. Years of applied dedication in hardware and software design have made each building block solid. Pervading all aspects is continual architectural diligence toward a consistent, logical system structure that allows an easy evolution into the future, appropriately re-using proven foundations from the past. Also pervasive is a maintenance sub-architecture which delivers built-in "intelligence" and "self-healing" abilities for systems at all levels. The software controlling Avaya Servers -- Avaya Communication Manager (Avaya CM) software -- plays a central role in achieving high availability as more than 30 percent of the lines of code in this software is devoted to the maintenance subsystem. Avaya CM software application is designed to automatically and continually assess performance, detecting and correcting errors as they occur. The software incorporates component and sub-assembly self-tests, error detection/correction, system-recovery, and alarm-escalation paths. Its maintenance subsystem manages hardware operation, software processes and data relationships.

Employing the IP packet-based transport architecture allows additional reliability advantages. One example is the load-sharing and fail-over ability of the principal IP resources found in Avaya's Media Gateways:

- C-LAN (Control LAN) Circuit Module (provides TCP/IP stack processing and socket management)
- Media Processor Module and the IP Media Resources 320 (provides conversion between VoIP and TDM (Time-Division Multiplex), where necessary, as in IP calls accessing the public-switched telephone network)
- VAL (Voice Announcements over LAN; allows recorded announcements to be stored and distributed anywhere on the LAN/WAN)

The IP architecture also allows phones to have a recovery mechanism of their own, so they can connect to alternate controllers (re-home) if the link to their primary system is broken.

For large enterprise systems, Avaya S87xx Servers running Avaya Communication Manager Software provide server redundancy, with call and feature preserving fail-over, on the strength of a Linux operating system. The Avaya S8300, S8400 and S85xx Servers can further enhance redundancy by serving as survivable processors within networks. Survivable Processors can take over population segments that have been disconnected from their primary call server and provide those segments with Avaya CM Software operation until the outage is resolved. Enterprise Survivable Server (ESS) can run on S87xx or S85xx, and provides full CM featured back-up of the entire Enterprise if desired. Avaya's S8300 and S8400 Servers leverage the strength of the proven Linux operating system for small systems and best of all, the integrated capabilities within Avaya Communication Manager work the same, albeit with slightly differing capacities. So it will be possible to use the Avaya S8300 C, S8400, S8500B/C, S8510, S8710, S8720, and S8730 Servers with Avaya Communication Manager 5.x.[1]

With converged infrastructures, the likelihood of mixed vendor environments is high. In addition, a converged infrastructure can involve a more distributed system. The degree of distribution will vary by situation, and will affect the overall reliability of the system. Each Enterprise Communication Management staff will need to assess their overall system reliability by understanding the nature of each building block, and how the building blocks work together. For example, a system that requires 99.99% availability may well require individual building blocks that are close or equal to five (5) nines (due to the combinatorial effect), and/or connections that provide alternate communication paths. Tables included in this document specify the reliability performance of Avaya Server and Avaya Media Gateway building blocks.

In sum, the architecture of Avaya Communication Manager Servers and Media Gateways make use of many elements on each level to help assure high overall system availability, and to meet the needs of demanding enterprise manager.

[1] Avaya will support S8700 only until Avaya Communication Manager 4.0.

## Introduction

The purpose of this paper is to provide the reader with medium-depth insight on the subject of communication-system "availability," specifically that of Avaya Servers and Media Gateways. The discussion that follows demonstrates Avaya's long-standing diligence in hardware and software design for high performance and reliability, and the overall architectural strength, consistency and foresight inherent in Avaya Communication Manager products.

A brief description of "availability" and its significance to communications systems is provided, as is specific data for Avaya Servers and Media Gateways, plus historical field-performance summary data. Hardware-design considerations, software-design considerations and overall maintenance strategy are described as well.

Avaya Communication Manager software and Avaya Servers are designed to deliver extremely high levels of availability. Hardware and software components are constructed to minimize the impact of component, function, or data failure. The maintenance architecture incorporates a multi-faceted ability to diagnose and remedy potential causes of failure, and to enable rapid service restoration when a problem occurs.

## High Availability – A Definition

The reliability of maintained systems is often expressed in terms of ***availability***. Availability is defined [2] as the percentage of time that the system is operational from the end-user perspective. The basic formula for calculating ***availability*** is:

Availability = MTBO / (MTBO + MTTR), where

- MTBO - Mean Time Between Outage measures the length of time between outages.
- MTTR - Mean Time To Recovery MTTR measures the time to recover.

Table 1 shows the range of ***availability*** that is typically expected of communications systems.

| Total System Availability [3] | Downtime per Year | Who Might Need This |
|---|---|---|
| 99.99<br>"four nines" | 53 minutes | Generally accepted as the minimum standard of acceptable down-time for business. |
| 99.995 + | 15-20 minutes | Businesses or organizations that potentially have a lot at stake on any given phone call. |
| 99.999+<br>"five nines+" | 5 minutes or less | Hospitals, Emergency Services, High-Performance Call Centers, Critical Government Agencies, Financial Institutions, etc. |

**Table 1: System Availability and Related Annual Downtime Allowance**

## High Availability – General Design Considerations

When designing communications hardware and software, high availability must be incorporated from the beginning as a primary performance requirement. High availability requires dedicated design diligence at multiple layers and with several overarching objectives.

[2] For telecommunications equipment, industry-recognized specifications as documented in various IEEE publications, Bellcore / Telcordia GR 512, and MIL-HDBK-217C are most commonly used for reliability and availability characterizations. See Appendix A for more information on prediction modeling used by Avaya designers.

[3] Total system availability is made up of all hardware and software elements that can effect the intended system operation. This is more comprehensive than hardware characterization of the processors, only.

| Design Element | Measurement |
|---|---|
| 1. Failures of each component and sub-system must be infrequent. | Mean Time Between Failures (MTBF) |
| 2. System outages must be infrequent. | Mean Time Between Outage (MTBO) |
| 3. When there is a failure or outage, the impact must be minimized and isolated; recovery must be speedy. | Mean Time to Recovery (MTTR) |
| 4. System collects its own performance statistics. | Various |

**Table 2: Design Elements for Meeting High Availability**

Not only must failures at the device or sub-assembly level be minimized, but when a failure occurs, the design itself must help alleviate the impact of the failure. For example, the design must test itself frequently, to root out problems before they become customer-affecting. The design must isolate sub-assemblies that are not functioning properly, and test them for verification. If a fault is identified, the circuit should be taken out of service, if necessary, with an alarm sent automatically to have a technician dispatched. As appropriate, the design must incorporate redundancy at the device or sub-assembly level to add reliability where it's most needed.

As an example of the extent to which maintenance architecture is intrinsic to the system design, consider that more than 30 percent of the lines of code within Avaya Communication Manager software instance is dedicated to system maintenance. In addition, a similar ratio of maintenance code is included in Avaya firmware that runs the circuit modules, interoperating with higher-level Avaya Communication Manager software maintenance.

## *Hardware Considerations*

Tables 3 and 4 demonstrate that circuit modules and sub-assemblies used in Avaya's Communication Manager related hardware platforms are extraordinarily reliable relative to the information-technology industry in general.

| **Industry Data** | |
|---|---|
| **Component** | **Mean Time To Failure** |
| Logic Boards * | 3 – 20 years |
| Disks * | 1 – 50 years |
| ISP Server Class Power Supply*** | 20 – 25 years |
| Power (North America) * | 5.2 months |
| LAN * | 3 weeks |

| **Avaya Platform Elements** | |
|---|---|
| **Component** | **Mean Time To Failure** |
| Media Processor board ** | 35 years |
| Protocol Preprocessor board (C-LAN) ** | 50 years |
| Digital Line/Trunk boards ** | 72 – 77 years |
| Avaya Media Server Complexes | 10-90+ years |
| Avaya (Gateway) Power Supplies ** | 25 – 60 years |
| (Industry) Power (North America) * | 5.2 months |
| (Industry) LAN * | 3 weeks |

* Taken from "Microsoft High Availability Operations Guide" (see footnote[4])
** Based on numerous internal Avaya studies assessing the results of millions of user-hours [5]
*** Based on internal survey of reputable vendors
(All numbers assume 24 hours per day, 7 days per week usage.)

**Tables 3, 4**

As can be seen in the numbers in Tables 3 and 4, the mean time between failures (MTBF) of each and every Avaya sub-assembly is World Class. This is not by accident. Avaya's heritage of achieving critical or "five nines+" availability results from holistic ownership of design, manufacture and lifetime support (stemming from an initial vision that's now been refined by tens of billions of hours of user experience). Avaya's living principles that enable this include:

- Highly effective knowledge and execution of "Design for Manufacture, Installation, Reliability and Serviceability":
  - ➢ End-to-end quality control executed thoroughly from electrical-device vendor partnerships through every stage of the assembly process. The highest quality is pushed to the earliest step of the process possible. Based on Deming's "zero defects and zero errors," which actually reduces overall costs substantially.[6]
  - ➢ Commonality that is leveraged at all levels:
    - – *Piece -parts*. Many of the "workhorses" of the product are in their 5th to7th generation of silicon integration. This keeps Avaya on the leading edge of technology curves.
    - – *Sub-assemblies* like circuit modules. Commonality here helps customers in a myriad of ways, not the least of which is investment protection. Like the piece parts, the sub-assemblies are also in their 5th – 7th level of renewal and refinement.

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[4] *Microsoft® Windows NT® Product Group High Availability Operations Guide*, Microsoft Consulting Services Manufacturing and Engineering Practice; © 1999, Microsoft Corporation.

[5] Availability modeling: Bell Labs "Reliability Information Notebook" (encyclopedia-like reference of multitudes of studies of pieceparts, sub-assemblies, environmental considerations, thermal modeling and testing, system modeling, etc.), 1980 – 1990; Joyce, 1987,1988,1991, 1995; Smith, 1987; Sueper, 1991; Mooney, 1992; Lincoln, 1999; Brown, 1993; Walters, 1998; Sueper, 1998; Vicker, 1999; Walters, 1998, 1999; Barnes 2000; Momken, 2001, 2002; Numerous extracts of field data from "Expert Systems" from 1992 – present; Factory studies of failure rates and field return data: each month of each year from 1987 – 2002.

[6] Gary Hamel, in his Leading the Revolution, speaks of the importance of "getting different" rather than "getting better." The "zero defects and zero errors" passion fostered by the Quality giant, Dr. Deming, in the 1980's was revolutionary. The prevailing notions of the times were that quality just needed to be "good enough" (obviously subjective) and that to increase quality beyond "good enough" would be cost prohibitive, with diminishing returns. The principle those notions missed is that if "causes" of quality problems are addressed, rather than "effects," then overall costs actually go down.

– *Shared designs*. Even where sub-assemblies can't be directly re-used, common designs that have been optimized for reliability over the years are reapplied in new configurations.

– *Common software*. Avaya CM software is the robust, feature-rich, field-proven software for high-reliability enterprise systems, common across Avaya's converged and traditional solutions.

➢ Server Platforms:

– *Qualification*. Server specification, selection and testing are rigorous. Requirements for ECC (Error-Correcting Code), and $N + 1$ fan as well as high reliable power supplies, as examples, are leveraged to assure high availability of the system.

- *ECC Memory* allows single bit and double bit errors to be managed by Avaya Communication Manager software. Single bit errors are detected and corrected. Double bit errors are detected, monitored and reported. The due diligence of the surround application working with the ECC enabled platform results in robust performance of memory.

- *RAID 1 feature of S8510 Server* provides the disk mirroring method and thus creates a set of data on both disks. Each disk works independent of the other and contains a complete copy of the data. In the event of a single disk failure, the system will continue with call processing and the various associated features. The replacement of the failed disk does not interrupt services. In addition to call processing the RAID 1 feature supports disk related activities such as backup/restore, general administration and maintenance tasks. RAID 1 feature is also offered as an optional feature on S8730 Server.

- *Server Redundancy feature of Avaya S87xx Servers* provides active/hot standby server complex. The servers contain a duplication module and memory writes are sent across a very high-speed fiber optic link for replication on the standby processor. Processor Ethernet of S8720 and S8730 server pair provide redundant control network connection between the servers and H.248 Media Gateways, IP-phones and selected adjuncts. Support of redundant control network connection between S87xx Server pair and IP Server Interface (IPSI) of Avaya Media Gateways is also offered as option. In this configuration active and hot standby IPSI are placed in the media gateway.

- *N+1 Fan Redundancy* assures that the server is operational when one fan fails. Simultaneously, the Communication Manager Software alerts services so that repair or replacement can be scheduled.

- *Option of Redundant Power Supply on both the Avaya S8510 and the larger Avaya S8730 Servers* assures that the server is operational in the event of single power supply unit failure. The power supply units are field replaceable. In the event of a single PS unit failure, the Avaya Communication Manager Maintenance Software will send a power supply failure alarm so that a replacement can be scheduled.

- *RAMDISK, or memory locking*, provides protection from disk failures. It locks application and critical components in memory. Typically, any device with moving parts will degrade overall reliability. Design must accommodate failures of moving parts, while maintaining service to end-users in parallel with dispatching services. RAMDISK allows a simplex platform, like the within the Avaya S8500 A and B Servers to continue to provide call processing in the event of disk failure, simultaneously with alarming to services for repair/replacement. It is essential for simplex platforms to support coverage for moving parts to assure 99.99% availability.

- *Partitioning of SSD and hard drive in S8400, S8300C and S8500C Servers* will improve overall operational reliability of these simplex systems. The most critical functions, such as operating system and Avaya Communication Manager Call Processing are stored on the very high reliability SSD with those less critical functions such as system log files, swap files and the messaging application are allocated to the hard disk drive. This partitioning allows the basic telephony services to continue to function even in the event of hard disk drive failure. In addition, to protect memory faults from SSD, the S8400 server will lock processes in memory.

– *HAP (High Availability Platform).* The HAP part of Avaya Communication Manager Software incorporates watchdog type monitoring of health and sanity of the applications, and the base operation system, as well as critical environmental conditions. Degradation of service results in simultaneous recovery strategies as well as alarming to services if necessary. The HAP requires hardware, such as the SAMP (*Server Available Management Processor) PCI card used in the S85xx server platforms.* This coverage is essential to assure 99.99% availability in a simplex system.

– *Details on specific platforms are provided in later section.*

➢ G650 Media Gateways

- Remote maintenance and alarming mechanism for error detection and maintenance
- Maintain stable calls in the event of short network outages
- N+1 fans
- Power Supply redundancy option
- Active-Standby redundancy option for IP interface to the S87xx server pair
- Separation of signaling and bearer traffic will provide resiliency in the form of protection from a single interface failing or being attacked maliciously
- Active-Active shared redundancy or Active-Standby redundancy option for IP media processing 320
- Active-Active N + 1 shared redundancy options for IP Media Processor boards (80 DSP channels)
- IP-endpoints, adjuncts and H.248 media gateways are pre-programmed with a list of alternate gatekeepers.

| Industry Data | |
|---|---|
| **Component** | **Mean Time To Failure** |
| Logic Boards * | 3 – 20 years |
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## *Software and Maintenance Architecture*

The maintenance architecture of Avaya Communication Manager Software is designed to detect and correct errors as they occur. This minimizes the number of events that cause system outages. It also quickly isolates the fault to a replaceable sub-assembly. This automatic assessment is done constantly, in the background of normal operation, so errors can be addressed early and proactively. Component self-testing, sub-assembly self-testing, error detection/correction, system recovery and alarm-escalation paths are all elements of this architecture. The system software has been designed to recover from intermittent failures and to continue providing service with a minimum of disruption. Firmware that runs each circuit module does similar tasks, working cooperatively with the system software.

The maintenance subsystem manages three (3) categories of maintenance objects. ***Hardware maintenance objects*** are tested and, where appropriate, alarmed and removed from service by the software. The error is reported to an operations center so the object can be replaced. The second category is ***software processes***; if a process encounters trouble, it is recovered or restarted. The third category is ***data relationships***; data relationships are audited and corrected.

**Figure 1**

[7] *Microsoft® Windows NT® Product Group High Availability Operations Guide*, Microsoft Consulting Services Manufacturing and Engineering Practice; © 1999, Microsoft Corporation.

[8] Availability modeling: Bell Labs "Reliability Information Notebook" (encyclopedia-like reference of multitudes of studies of pieceparts, sub-assemblies, environmental considerations, thermal modeling and testing, system modeling, etc.), 1980 – 1990; Joyce, 1987,1988,1991, 1995; Smith, 1987; Sueper, 1991; Mooney, 1992; Lincoln, 1999; Brown, 1993; Walters, 1998; Sueper, 1998; Vicker, 1999; Walters, 1998, 1999; Barnes 2000; Momken, 2001, 2002; Numerous extracts of field data from "Expert Systems" from 1992 – present; Factory studies of failure rates and field return data: each month of each year from 1987 – 2002.

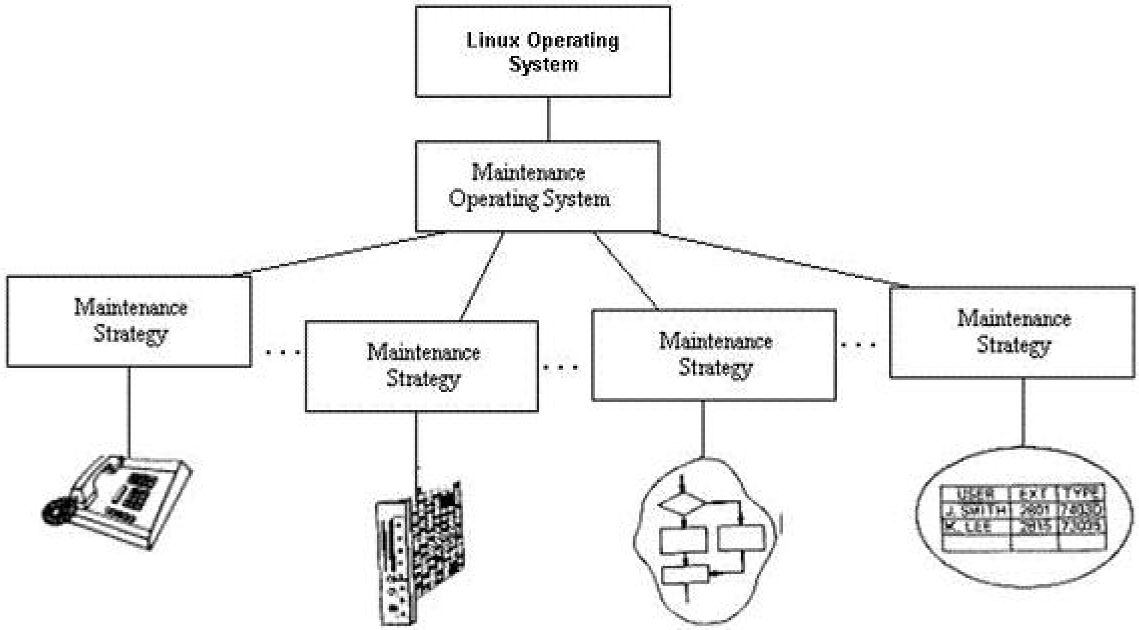


**Figure 1**

Avaya Communication Manager Software provides its systems with remote diagnostics capability, which enables rapid troubleshooting and different layers of maintenance. Studies have shown that most problems experienced by Avaya call-processing systems are self-corrected without impact to the customer. This sophisticated maintenance management capability makes possible the 99.99 – 99.999+ percent availability performance attributes of Avaya Communication Manager driven solutions featuring a mix of Avaya Servers and Avaya Media Gateways.

## *Software Failure Recovery*

One key to rapid self-healing of software failures is the judicious use of the appropriate level of recovery. With too little action when stronger measures should be taken, the attempted recovery wastes time and does not solve the problem. Conversely, with too much action, the recovery is unnecessarily prolonged. Figure 2 shows the spectrum of recovery levels used by Avaya Communication Manager Software.

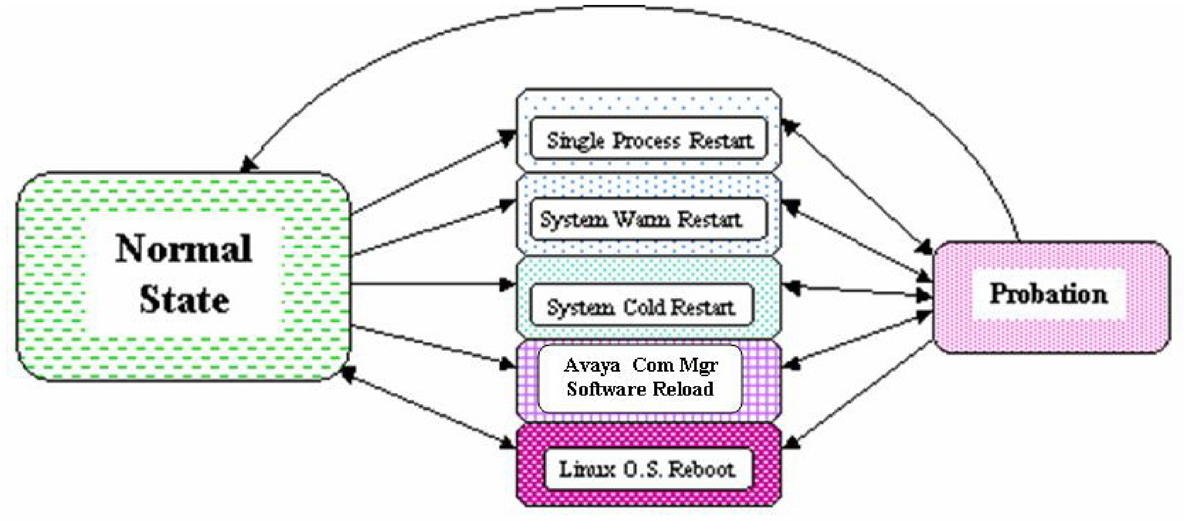


**Figure 2**
**Software Recovery Levels**

The automatic recovery levels are as follows (from mildest to strongest, which also happen to be from the quickest to slowest, and from the more frequent to less frequent):

**Single Process Restarts** –

Process sanity audits are performed routinely, every ten (10) seconds or so, on many dozens of key software processes. In the event of a hung process, that single process will be restarted (no call outage will result). If a higher-level restart or three (3) single-process restarts are needed within a sixty (60) second probationary period, the third single-process restart will be deemed ineffective and instead be escalated to a system **warm restart**.

**System Warm Restarts –**

This mechanism preserves all stable and held calls, as well as feature-activity data, throughout the brief recovery period. Processes are restarted, while maintaining call processing related data. If three warm restarts are needed within a fifteen (15) minute probationary period, the system warm restart be deemed ineffective and instead be escalated to a system **cold restart**.

**System Cold Restarts –**

In this recovery mechanism, processes are restarted, with some data intact, but all **calls are dropped** and ports are reset, followed by a "port board activation" phase of recovery. If three (3) cold restarts are needed within a fifteen (15) minute probationary period, the third system cold restart will be deemed ineffective and will instead be escalated to a software **reload**.

**Avaya Communication Manager Software Reloads –**

In this recovery mechanism, all **calls are dropped**, and all processes related to call processing are killed and restarted. Port-configuration data known as "translations" is re-read from disk and (as in system cold restarts) ports are reset and port boards are activated. If two software reloads are needed within a fifteen (15) minute probationary period, the reload will be deemed ineffective and instead be escalated to an operating system **reboot**.

**Linux Operating System Reboots (applicable to Avaya Servers S8300, S8400, S85xx and S87xx Servers)** –

In this recovery mechanism, all **calls are dropped**, all processes are killed, and the operating system is completely rebooted. Processes are then read off disk and loaded into memory, where recovery then proceeds exactly as it does in Software reloads. If the reboot fails after a recent software upgrade, another reboot will be attempted, but from a disk partition containing the previous version of software.

In the Avaya S87xx duplicated Servers, the ***server interchange*** adds graceful fault tolerance during any of the events above or in case of impending hardware failure. See the S87xx section below for more information.

## *Avaya S8400, S85xx and S87xx Servers*

While all businesses require solid performance from their communications systems, some businesses may require increased levels of availability for some or all of their distributed system. To meet that need, the Avaya Servers and their associated Avaya Media Gateways accommodate a range of availabilities. Table 5 shows the configurations that support the range of availability. For more information, see the case studies in Appendix C.

| Avaya CM System Availability [9],[10] | Downtime per Year | Category | Configuration |
|---|---|---|---|
| 99.99 | < 53 minutes | Basic level of service. | Single Call Control Processor; reliable Data Network supporting call control signaling to MG |
| 99.995 | < 15-20 minutes | Enhanced level of service | Single Call Control Processor; Survivable Processor back-up; redundant Data Network link supporting call control signaling to Media Gateways; N+1 trunks and media processing resources |
| 99.999+ | < 5 minutes | Highest level: Hospitals, Emergency Services, High Performance Call Centers, Critical Government Agencies, Financial Institutions, etc. | Duplicated Call Control, redundant Data Network connection support call processing signaling; Cluster of Media gateways provide N+1 trunks, signaling and media processing resources at each data center site |

**Table 5: Redundant Critical Components is one of the key Elements in meeting 99.999%+**

In fiber connected legacy configurations, the whole system was a closed system. Availability was characterized at a system level. Traditional terms, “standard”, “high”, and “critical” were used to categorize the levels of availability. Figures 3, 4 and 5 depict these three (3) traditional levels. Note that Center Stage and ATM are no longer supported for new shipments beyond Avaya Communication Manager 2.x. Nevertheless, existing installations are significant and continue to be supported.

[9] This availability prediction does not include availability of the customer’s data networks, PSTN (Public Switched Telephony Network) contributions, or contributions due to power outages (all of which can vary depending upon implementation). Note that with “open systems,” the customer must model their systems end-to-end to ensure availability that meets their objectives. In all systems depicted in this paper, the minimum numbers of data switches have been included in the analysis. Actual systems are likely to have more data switches. A very conservative MTTR of 4 hours is assumed, inclusive of technician travel time, but availability can be improved with reduced MTTR, if customer has on-site technician and sparing strategies. See appendix for reduced MTTR calculations.

[10] The number shown for system availability is based on Avaya Server complex, as well as local and remote gateways. See appendices for breakdown of contributions.

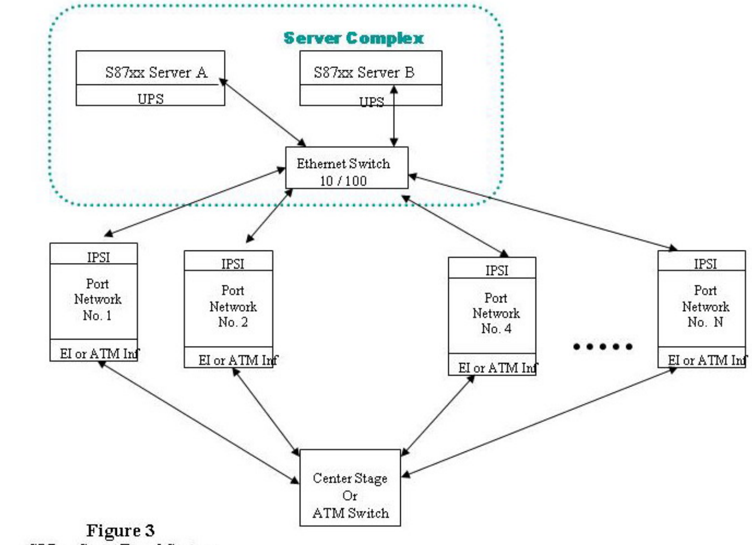


**Figure 3**
**S87xx Sever Based System**
**"Duplex" or Standard Reliability**

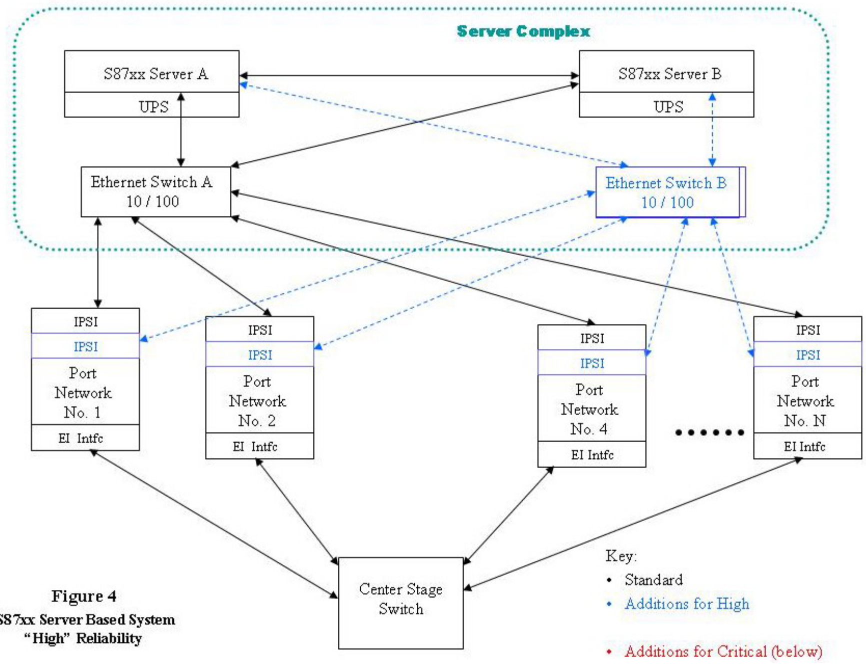


**Figure 4**
**S87xx Server Based System**
**"High" Reliability**

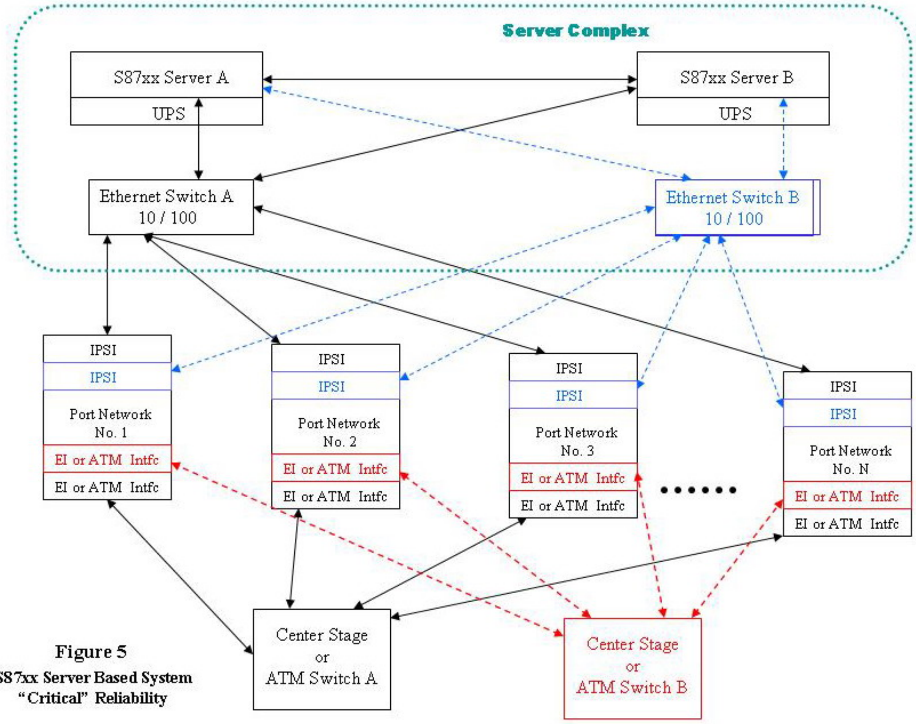


**Figure 5**
**S87xx Server Based System**
**"Critical" Reliability**

The Avaya S8xxx series server and associated architecture increasingly employ the data network. Beginning with Avaya Communication Manager (CM) 3.1 duplicated bearers over IP is supported in the IP Media Resource 320. This along with the duplicated signaling via IP Server Interface (IPSI) boards result in a robust 99.999% availability solution (assuming a robustly designed network). The use of the data network means that the system is no longer closed, and the overall availability depends upon the underlying data network, as well as that of the Avaya Servers and Media Gateways. Avaya Servers and Media Gateways availability and MTBF information is provided in Appendix A.

Figure 6 shows an S87xx system with full duplication of bearer and signaling over the data network.

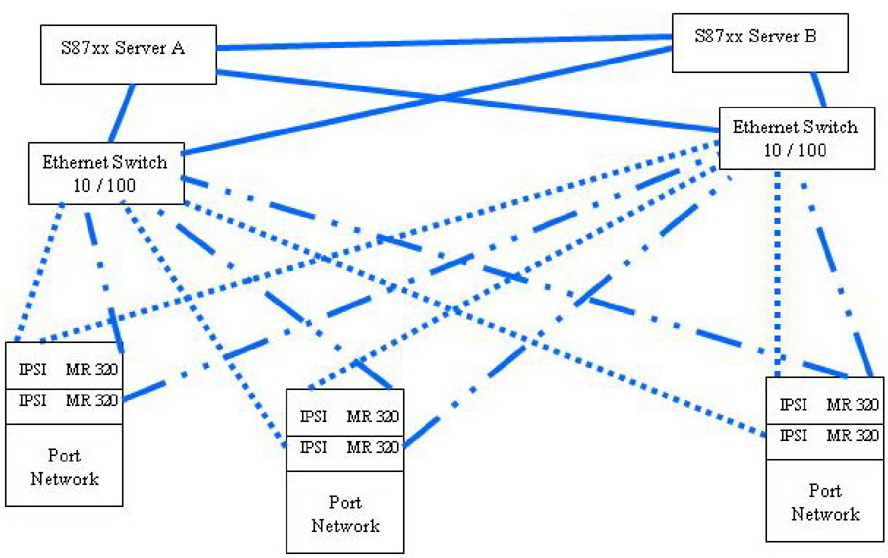


**Fig. 6**
**S87xx Server Based System:**
**Duplicated Control (IPSI)**
**Duplicated Bearer (MR 320)**

Also, beginning with Avaya Communication Manager 3.0, systems can support a mix of port network (PN) types in terms of simplex versus duplex as well as cabinet type. And, systems with traditional Center Stage Switch equipment can be mixed with the newer architecture. This flexibility affords a high level of investment protection. This also provides flexibility for customers to have higher availability in areas just where they need it.

Figure 7 shows a system that has both Center Stage connected port networks and IP connected port networks. This system also contains a mix of port network cabinet types, and a mix of duplicated and simplex port networks.

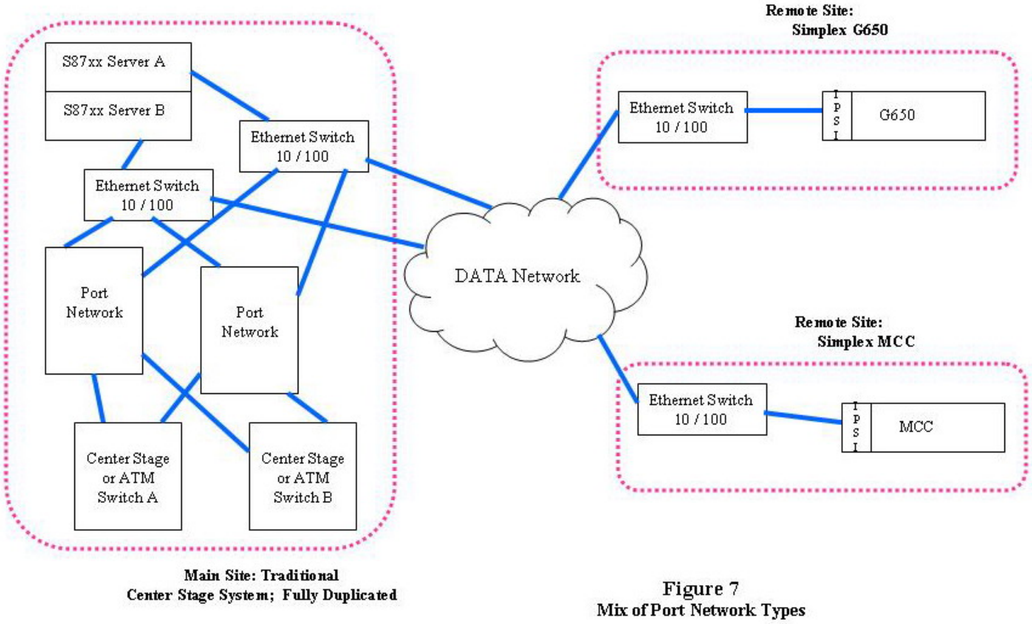


Figure 7
Mix of Port Network Types

Beginning with Avaya Communication Manager 5.2, S8730 Servers with Processor Ethernet Duplication provide high availability to H.248 media Gateways and H.323 IP phones that are connected to the Processor Ethernet of Avaya CM.

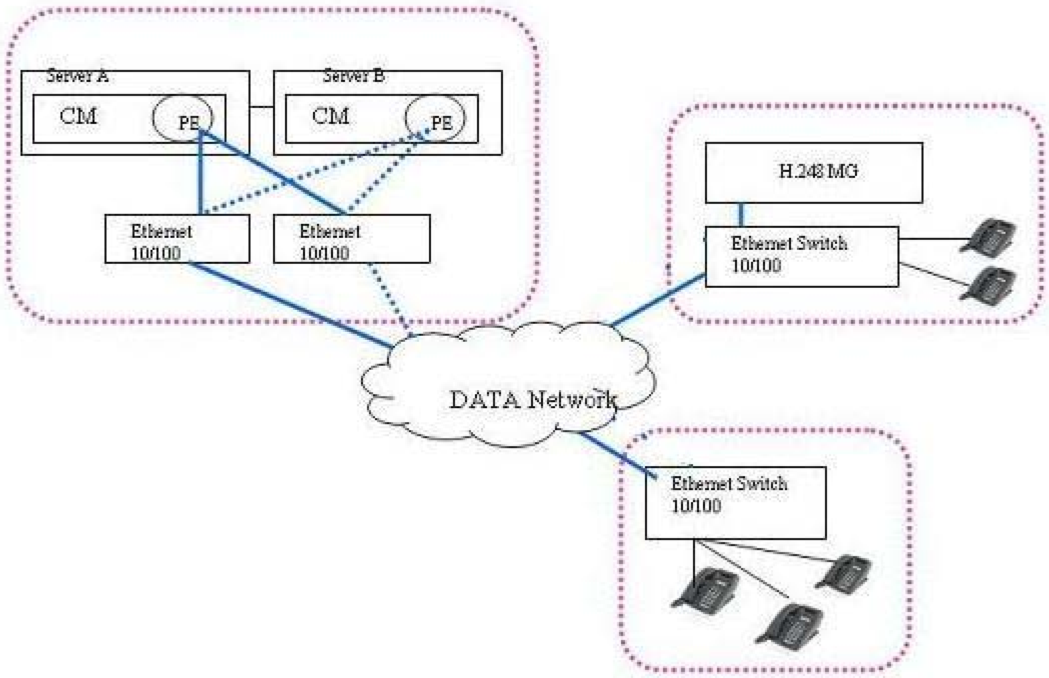


**Figure 8: S8730 Server Pair support Remote IP-phones and H.248 Media Gateways on Processor Ethernet for Duplex Servers**

Processor Ethernet is an IP interface on a server which is available on both simplex and duplex servers (Avaya CM 5.2 and beyond). Processor Ethernet feature on duplex servers allows for pure IP configuration and supports high availability for H.248 Media Gateways and selected IP phones without the need for port networks in the configuration. With Avaya Communication Manager 5.2 this feature is supported on Avaya S8720 Servers and Avaya S8730 Servers.

Selected IP phones[11] and trunks will be connection preserving across server interchange. This means stable calls will stay up during server interchange. Although features such as hold, conference, etc are not available during server interchange, normal operations will resume following the server interchange.

The high-availability philosophy is scrupulously implemented in the Avaya Servers. Consider the following:

- Linux was selected as the operating system (OS) for many reasons, principal of which are:
    - Access to full source code makes it possible to more rapidly fix operating system bugs.
    - Linux facilitates easy system customization to include high-availability enhancements.
    - Linux has fewer known security flaws than other operating systems, and facilitates system customization to provide further security.
- High-availability enhancements:
    - Software sanity is continuously evaluated. Any insanity due to unexpected conditions is detected, and, until normal operation is restored, the offending software is forced to go through escalating levels of recovery. Ultimately, with an Avaya S87xx Server driven Communication Manager Software, the entire active software processing can switch over to a standby server.

[11] 96xx and 46xx sets which are Time to Service aware and upgraded firmware to support this feature will stay call preserving during the server interchange. 47xx Agere sets and 16xx endpoints will have to reset and re-register during server interchange.

- Disks are partitioned to keep most of the variable information away from the invariant and to allow for automatic recovery if newly loaded software fails. In the case of S8400, Solid State Device (SSD) technology is used.
- All event logs are proactively scanned for potential service-affecting items. If found, alarms are generated. If necessary, a service dispatch is launched.
- Applications running on the operating system are thoroughly pre-tested to assure proper performance; this operating system is closed to any applications other than those provided by the manufacturer to avoid interference with operation. Alarms can be generated if any untested software is loaded on the system.
- Eliminating the need for customers and technicians in most cases to access the operating system shell directly provides protection from inadvertent adverse alterations to the system.
- Tools have been enhanced to allow secure, remote, non-stop debugging of the system as well as unattended data collection.

- Avaya S87xx Server highlights: Two (2) servers with a memory-shadowing link allow:
  - One processor to take over if the other fails, without dropping calls.
  - Simple duplication of all other server components (e.g. modem, disk, memory), eliminating a single point of failure.
  - Connections are preserved during upgrades.
  - Option of RAID level 1 feature with the Avaya S8730 Server
  - Option for Power Supply Unit Redundancy with the Avaya S8730 Server
- Avaya S8510 Server running Avaya Communication Manager software
  - This Avaya Server is equipped with Remote Maintenance Board, Server Availability Management Processor (SAMP), for remote maintenance, administration and alarming purposes. Any degraded service results in prompt alarming to services, even if the server or operating system goes down. This monitoring function will also reset the server as recovery escalation directs. The software used in these processes is referred to as the HAP (High Availability Platform).
  - Server hardware system is equipped with the hardware version of RAID level 1 feature. This feature will provide the disk mirroring method and thus in the event of a single disk failure, the system will continue service.
  - Server has two external Ethernet Interfaces on the motherboard and two external Ethernet interfaces on the Dual NIC (Network Interface Card), which is a Field Replaceable Unit. The Dual NIC architecture will provide the option for isolation of the "control network A" from the corporate/customer LAN (Local Area Network) access and thus protection of the control network from DOS (Denial of Service) attacks and congestions.
  - Redundant power supply unit is offered as an option
  - N+1 fan units supporting cooling system for processor and power supply units

- Avaya S8500B/C Server running Avaya Communication Manager software:
  - Embedded remote maintenance board (SAMP) monitors the health and sanity of the Avaya Communication Manager application, and base operating system, in addition to critical environmental conditions. Any degraded service results in prompt alarming to services, even if the server or operating system goes down. This monitoring function will also reset the server as recovery escalation directs. The software used in these processes is referred to as the HAP (High Availability Platform).
  - RAM DISK operation allows call processing to continue for at least 72 hours after hard disk failure. Initial degraded operation of disk generates alarms to services.
  - Redundant fans.
  - Industrial grade power supply.

- Avaya S8400 Server:
  - Proven Linux platform in a circuit pack with a TN-form factor.
    - Provides very solid upgrade path for Avaya DEFINITY® Server CSI and Avaya S8100 Media Server.
  - Embedded remote maintenance function monitors the health and sanity of the Avaya Communication Manager application, and base operating system, in addition to critical environmental conditions. Any degraded service results in prompt alarming to services.
  - Solid State Device (SSD) replaces the conventional hard drive and is used for the operating system and Avaya Communication Manager software. SSD has better availability performance than traditional hard drives because there are no moving parts.
  - Reliability comparable to, or better than, Avaya DEFINITY® Server CSI.
  - Redundant fans.
  - High grade industrial power supply.
  - Optional duplicated power supply in an Avaya G650 Media Gateway configuration.
  - One port network is supported, and up to five (5) H.248 Media Gateways.
  - Local Survivable Processor (LSP) configuration is supported for back-up of the H.248 Media Gateways.
- All Avaya Servers support the following:
  - **Locally Sourced Announcements and Locally Sourced Music On Hold (MoH**), introduced in Avaya Communication Manager 3.1,: the same announcements and/or MoH sources can be deployed in different parts of the network. This provides back-up, while assuring the closest possible source.
  - **Automatic restoration of the most recently saved versions of translations**, following a power outage. Translations are automatically shadowed onto the standby server as well of a duplicated server pair. [Note: with Avaya G700 and/or G450 Media Gateways, translations can also be copied to Local Survivable Processors for automatic recovery in the case of network partitioning or complete central site failure.]
  - **Scheduled backups of critical system information, locally and/or at remote sites.** In an emergency, multiple copies of translations and server-configuration information are available. Saved information can be quickly restored.
  - **TTS (Time to Service),** Introduced in Avaya Communication Manager 4.0, reduces IP endpoint time to service, especially in cases where the system has many IP endpoints re-registering simultaneously. This feature also prevents IP-phones from losing their registration during short network outages.
  - **IP Trunk Link Bounce,** Introduced in Avaya Communication Manager 4.0, allows some administrable time for the IP network to recover before taking down the trunk. With this feature, calls would still be disrupted during the network outage, but recovery time after the outage would be minimized for network outage of typical duration.
  - **IP end points and H.248 Media Gateway Connection Preserving Failover** allows the bearer connection of stable calls to be preserved when the IP end points or the H.248 media gateways failover to another server, or LSP, or return to their primary server.

## *Avaya CM Systems Survivability*

Systems operation in the face of network fragmentation requires that call control back-up be distributed in the network. Avaya offers several layers of survivable call processing that can be used separately or in conjunction with each other.

For smaller locations' survivable needs, the Local Spare Processor (LSP) is available with the Avaya S8300B/C Server and as of Avaya Communication Manager (CM) 3.1, the Avaya S85xx Server:

- Supports H.248 Media Gateways.
- Each Avaya S8300 LSP supports up to 450 users and each Avaya S85xx LSP supports up to 2,400 users.

- Up to fifty (50) LSPs can be supported on single S8300 system and up to two hundred fifty (250) LSPs can be supported on a single S85xx system.
- Connection preserving failover and fail-back are supported.
- Administrable choice of several auto fail-back options.
- Inter Gateway Alternate Routing (IGAR) will redirect bearer connection between port networks and gateways when IP-WAN is incapable of carrying this traffic.
- H.248 Media Gateway Standard Local Survivability (SLS) provides basic call control ability if the main server connection is lost.
- Single remote Port Network has the survivability option with an S8400 ESS residing in the Port Network. The S8400 ESS is a new feature in Avaya Communication Manager 5.2 and it only supports an IP connected Port Network (G600, G650 or MCC1 Media Gateways.)

For larger locations' survivability needs, Enterprise Survivable Server (ESS) is available with S85xx or S87xx systems:

- Supports 64 Port Networks and 250 H.248 Gateways.
- Each ESS supports up to 36,000 users (of which 12,000 can be IP endpoints).
- 63 ESS local and/or (7) enterprise-wide up to CM3.0; 63 ESS local and/or enterprise-wide as of Avaya Communication Manager 3.1.
- 250 LSP servers can be supported on a single system.

Since WAN (Wide Area Network) availability can be a serious bottleneck in overall availability, the options for local call control at remote sites is a vitally important part of the architecture. This table illustrates how much local call control uptime can be regained at remote sites by virtue of LSP (Local Survivable Server) or ESS (Enterprise Survivable Server) back-up.

| IF WAN Availability is: | Annual Uptime Pay-Back with ESS / LSP | | |
|---|---|---|---|
| | Minutes | Hours | Days |
| 99% | 5251 | 87 | 3 1/2 |
| 99.5% | 2623 | 43 | 1 3/4 |
| 99.9% | 521 | 8.7 | |
| 99.99% | 48 | 0.8 | |

**Table 6**

Figure 9 shows an example of a networked configuration that uses an Enterprise Survivable Server (ESS) cluster to provide back up call control. Note that the first ESS cluster is set up to support the whole enterprise, should connectivity to the Main call servers be lost. The second ESS server shown here is set up for local support should connectivity to the Main S87xx and first ESS cluster be lost. Users on "cloud B" have three (3) possible connections to call control servers, and will have service even if connections are lost to the Main or first ESS cluster.

IP endpoints can be downloaded with up to 8 alternate gatekeeper addresses upon initial connection with a DHCP (Dynamic Host Configuration Protocol), and over 30 addresses upon successful registration with an Avaya Communication Manager. The endpoints will re-home to designated alternative gatekeepers such as CLAN's, LSP or ESS servers if connectivity to the primary is disrupted.

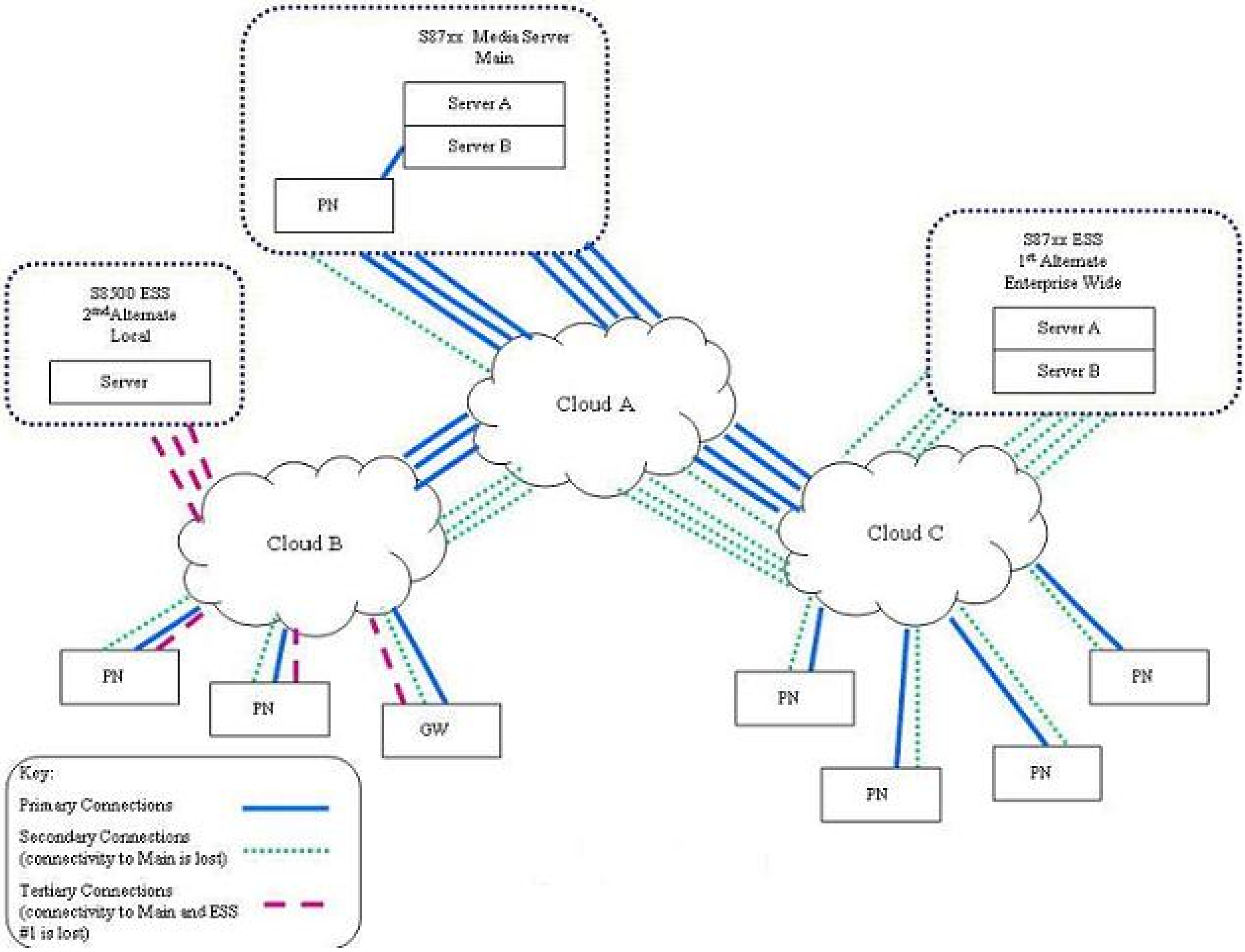


**Figure 9: ESS Example**

IP Trunk automatic fail-over (and automatic fall-back) to (and from) a traditional PSTN (Public Switched Telephony Network) trunk is supported. In this configuration, the customer's system administrator sets service-quality thresholds for delay and/or packet loss. Fall-back thresholds can be set at a level more conservative than the fail-over levels to prevent unstable (thrashing) conditions. If an IP trunk is experiencing impairments that exceed the thresholds, new calls will be routed over the designated PSTN trunk, in lieu, until such time as the service quality has returned to acceptable levels.

## Port Network Recovery Steps during Control Network Outages

Port Network survivability through short network outages is significantly improved with Avaya Communication Manager 5.2.. The survivability time line is depicted in Figure 10:

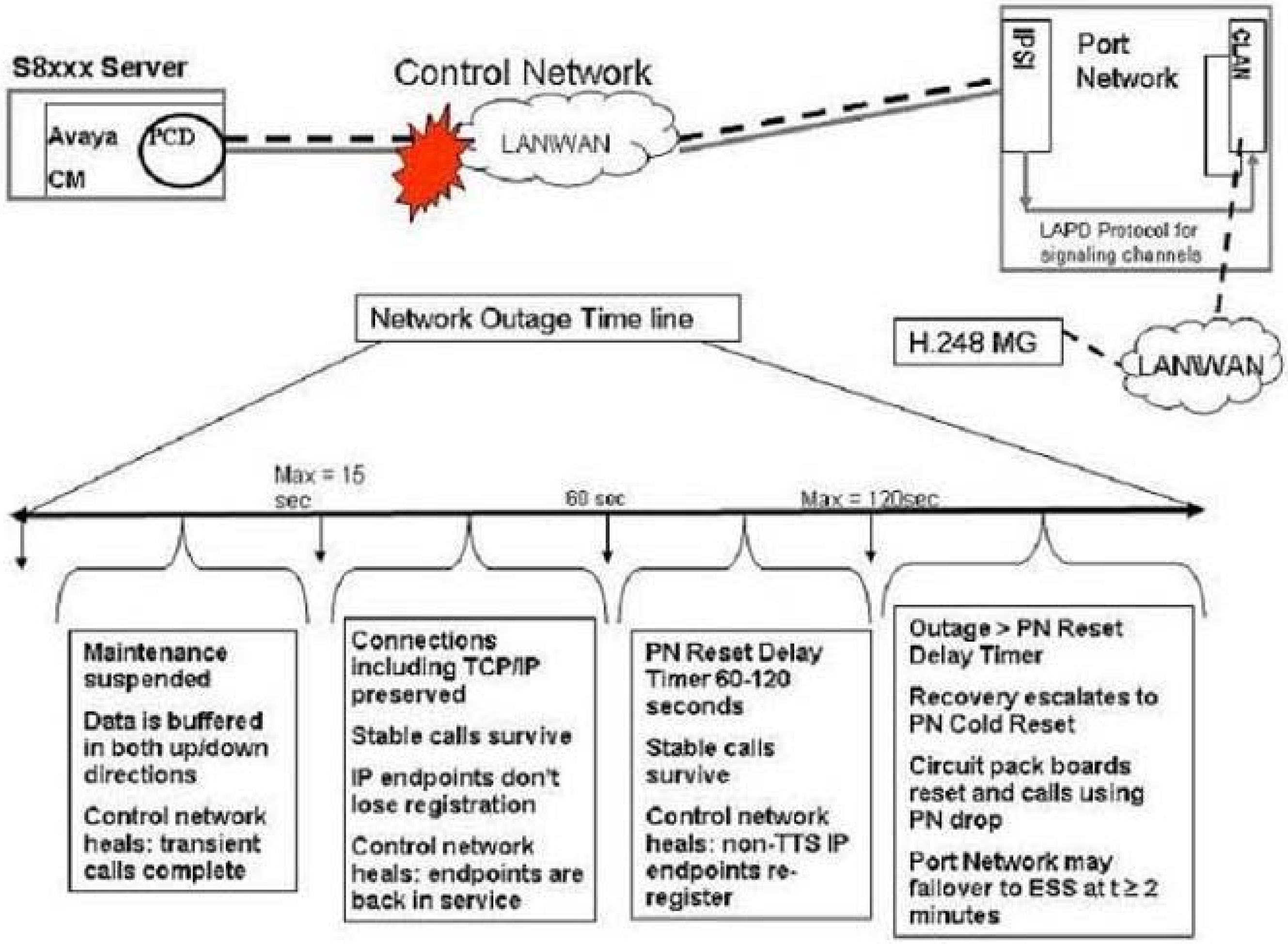


**Figure 10: Avaya CM 5.2 Improved Port Network (PN) Recovery from Control Network Outages**

**IP-phones Time to Service** (or TTS enabled endpoint) is a feature which improves the time required to bring an IP phone into service by reducing the amount of required signaling for a phone to reach the in-service state. Once a phone is registered to an Avaya Communication Manager Server, TTS keeps the registration persistent for a relatively long Time to Live (hours) regardless of TCP connection failure, network outages, or even restarts of the endpoint. This significantly reduces the number of times that IP phones need to re-register with the server due to outages.

## *Avaya S8300 and S85xx Servers and Branch Media Gateways*

The Avaya S8300 Server and Avaya S8500 series Server, like the S87xx Server, accommodates several levels of availability performance. Both S8300 and S8500/S8510 Servers are designed to provide a complementary option: Local Survivable Processing (LSP) for the Branch data center. The LSP architecture provides additional availability and survivability within a network of small-to-medium-sized offices.

Examples of the branch media gateways are: Avaya G450, Avaya G430, Avaya G700, Avaya G350, Avaya G250 and the Avaya G150.

Table 7 depicts the Avaya S8300 and S8500 series Servers and Branch Media Gateway availability possibilities.

| System Availability [12, 13] | Downtime per Year | Who Might Need This | Configuration |
|---|---|---|---|
| 99.99 | 53 minutes | Virtually everyone needs at least this level of service at remote sites | Single ICC (internal call controller) equipped Media Gateway per site |
| 99.999 | 5.3 minutes | Hospitals and Businesses or organizations that potentially have a lot at stake on any given phone call | N+1 media gateways at each site; each site has duplicate interfaces to the data networks; each IP endpoint homed to at least 2 systems run by Avaya™ CM Software (e.g. S8510 Primary and S8300LSP, or otherwise).[14] For more info see Appendix C. |

**Table 7: Avaya S8300/S85xx Server and Branch Media Gateway System Availability Value**

- Avaya S8300/S8500 series Server and branch Avaya Media Gateway basics:
  - **Embedded remote maintenance function** monitors the health and sanity of the Avaya Communication Manager application, and base operating system, in addition to critical environmental conditions. Any degraded service results in prompt alarming to services, even if the Avaya server or operating system goes down.
  - **Connection Preserving Failover and Failback:** When Avaya H.248 Media Gateways fail-over or fail-back to any Avaya Server, stable calls are held up. Failback options can be immediate, or administered.

- Avaya S8300 Server enhancement options
  - **Local Survivable Processor (LSP)** and/or **Enterprise Survivable Server (ESS)** for back-up call-control.
    - Up to 50 LSP servers can be supported in an Avaya S8300 System
    - The H.248 Media Gateways can be subtended off of an ESS.
    - LSP / ESS servers support the full Avaya Communication Manager feature set.
  - **Standard Local Survivability (SLS):**
    - Avaya G250, G350, G430 and G450 Media Gateways contain call very basic control ability.
      - Takes over local call control if the main server connection is lost.
      - Local outbound trunks and internal calls are supported.
      - Incoming trunk calls can be delivered to available stations.

[12] This availability prediction does not include availability of the customer's data networks, PSTN contributions, or contributions due to power outages (all of which can vary depending upon implementation). A conservative MTTR of 4 hours is assumed (includes nominal travel time); availability can be improved with reduced MTTR, if customer has on-site technician and sparing strategies.

[13] The number shown for system availability is based on server complex, as well as local and remote gateways. See appendices for breakdown of contributions.

[14] Note that Avaya IP phones have multi-homing abilities. They can be configured to re-home to any Avaya Communication Manager's controller. For example, in a configuration with S87xx at a main site and S8300 / G700 or G450 at remote site, the phones at the remote site could re-home to main S87xx through separate Ethernet switches. This configuration could be said to therefore provide 99.995% availability as well.

- **Dial-up Backup feature** provides low cost back-up support of WAN connectivity in the Avaya G250 G350, G430 and G450 Media Gateways.
    - This provides a backup path in case of WAN (Wide Area Network) failure.
    - Call control signaling to the main server is re-routed from the WAN to the PSTN.
- **Avaya G450 Media Gateway**: As an H.248 remote branch gateway designed to meet high availability with the option of duplicated replaceable power supply unites. The following critical components are field replaceable units
    - Supervisor board,
    - DSP VoIP cards
    - Power Supply Unit (s) (which can be duplicated and are hot-swappable in duplicated configuration),
    - Fan Units.

  Hence replacement of failed component and time to restore service is within minutes. The replacement of media modules does not require power down and they are hot swappable.

## *Availability Considerations in the Data Network*

Availability of any VoIP system requires consideration of the data network as well. Data networking has evolved in an environment where 99 percent to 99.9 percent availability was considered acceptable. The quickest way to enhance this availability level is to create redundancy in the central parts of the data networks (the parts that affect many users if they fail). Cisco, for example, strongly recommends that customers who wish to implement VoIP create redundancy from the wiring-closet switches all the way through backbone structures. [15] [16]

Since redundancy of data-network elements is commonly deployed to support VoIP, the LAN interfaces from Avaya Server systems must be able to match this redundancy. In a G650 Media Gateway, the C-LAN (Control LAN) Protocol Preprocessor Media Processor and the IP Media Resource 320 can all be used in N+ 1 or multiples (to support the same regions of users) in a shared-resource fashion.[17] IP Media Resource 320 is typically provisioned with either one or two per Port Network. At an MTBF of roughly 50 years each, it is not likely they will fail. In the rare event of a failure, redundant boards assigned to the same region automatically take over support of the users originally using the failed resource. More significantly, assuming redundant LAN segments are connected to each C-LAN, if one LAN segment fails, users are provided back-up service through the redundant LAN segment(s) to the alternate C-LAN(s). Up to eight (8) "alternate gatekeeper" addresses can be downloaded to the IP telephones via either a DHCP server or the Avaya Media Server itself. The back-up boards can be local and/or remote, as long as they are on the same logical system.
In a recent architecture of S8730 with duplicated Processor Ethernet redundant LAN segments will support Call Control link to G450 Media Gateways. If one LAN segment fails, call control signaling will failover to the back up LAN segment connection to the MG.

For a diagram of possibilities created by this flexibility, see the case study in appendix C.

## Historical Data

Constant data collection and analysis is essential not only to corroborate initial expectations, but also to continually engage in improvement cycles. Avaya systems have a sophisticated self-monitoring and reporting architecture. The information provided by the systems, together with the sophisticated databases developed for Avaya Services support are collectively known as Avaya's "expert systems."

Avaya databases contain the history of 10's of millions of user hours, via remote reporting and other aspects of the Avaya Server maintenance architectures. With this data, corroboration of actual performance relative to anticipated performance can be made. Year after year, the results have verified the anticipation. The expert systems monitor system performance, initiate corrective measures when necessary, and collect data that certifies the validity of system designs and availability claims.

## Conclusion

In the Avaya Server and Gateway architecture, the transport, services and applications layers are implemented cleanly, allowing transport infrastructure to be independent of the services and applications that run on top of it. This flexibility allows Avaya's rich heritage of features and applications to carry forward on any transport topology that a customer desires to use, including IP. This same architecture also enables easy evolution and incorporation of future enhancements. Finally, a wide array of technologies and techniques that are "key" to making high reliability and availability possible are robustly implemented on each architectural level, both for Avaya Communication Manager Software and the Avaya Servers with Avaya Media Gateways that are powered by it. It is an architecture on which enterprises can build their business with peace of mind.

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[15] Gene Arantowitz, Cisco Systems; "Building a Converged End to End IP Telephony Network;" VoiceCon 2001.

[16] Note that unless battery holdover is part of the design of each element and/or UPS's are used to support each element, this implementation would still be limited by the MTBF and MTTR of North American Power.

[17] The Voice Announcements over LAN board (VAL) can be used in multiples for back-up, as well.

## Third Party Testing of Avaya Communication Manager Solutions for Delivering Service Continuity

In 2006 Tolly Group Inc tested Avaya Communication Managers (Multi-Vantage Solutions) for robustness and fast service continuity under adverse circumstances. The tested configurations, failure scenarios and results are documented in

***"Building Survivable VoIP for Enterprise, Leveraging Avaya MultiVantage Solutions to Deliver Business Continuity"***

http://www.tolly.com/ts/2006/Avaya/Survivability/TollyWP206107BuildingSurvivableVoIPfortheEnterpriseFeb2006.pdf

# Appendix A
## *Avaya Availability Analyses*

## Definition of Terms and General Formulas

It may be helpful to understand the terms used in technical discussions of operational robustness:

***RELIABILITY*** is a measure that indicates time between failures occurring in a system (observable by users or not).

***AVAILABILITY*** is a measure of the percentage of time a system or component performs its useful function for users.

***OUTAGE*** is a measure of time the system is not performing its useful function. Useful function has to be defined based on the application required. Here, we define it as call control to users.

Reliability measures how infrequently the system fails, at any level. Availability measures the percentage of time the system is in its operational state for the user population (i.e., larger than a single failure group). In the common vernacular, "reliability" is inaccurately used to refer to both of these aspects. For clarity's sake, this discussion adheres to the precise definition. See Figure 1 for the availability range applicable to communications systems.

| Availability | Downtime per year in … | | | |
|---|---|---|---|---|
| | Seconds | Minutes | Hours | Days |
| 99.9999% | 32 | | | |
| 99.9990% | 315 | 5 | | |
| 99.9900% | 3154 | 53 | | |
| 99.9000% | 31536 | 526 | 9 | |
| 99.0000% | 315360 | 5256 | 88 | 4 |

**Table 1**

To assure high availability:

- Failures of each component and sub-system must be infrequent, Mean Time Between Failures (MTBF), as MTBF measures length of time between failures).
- System outages must be infrequent, Mean Time Between Outage (MTBO), as MTBO measures length of time between outages.
- Once there is a failure or outage, recovery must be speedy, Mean Time To Repair/Recover or Restore service (MTTR), as MTTR measures this speediness.

The actual formula for availability is:

$$A = MTBO / (MTBO + MTTR).$$

When projecting the availability of a system composed of subsystems, a model that logically equates the subsystems' availability to the total system availability is created. In turn, the availability of each subsystem is modeled based on a composite of its components.

***FAILURE GROUP*** is the number of users affected by an outage that is going to be "counted" in the overall availability calculations. Per the Telcordia standard[18], "the actual time duration of a partial outage is weighted by the fraction of terminations (users) affected by the outage condition." For example: for an outage of 20 minutes affecting 10% of the users, the contribution to overall downtime is 10% X 20 minutes = 2 minutes. In the case of IP endpoints, the calculations in this document are based on failure group sizes as low as one. This is by virtue of the dynamic assignment of CLAN and Media Processors resources (no hard connections creating a single point of failure assuming at least N+1 redundancy).

As another example, in the case of TDM connections, say 24 users are served by a digital Circuit Pack, TN2224. The impact may be calculated:

***(24 users impacted/1000 total users)*** x ***outage duration***.

Since the MTBF for the TN 2224 is 45 – 50 years and if an MTTR of 4 hours is assumed, then the total downtime hit from that Circuit Pack (CP) is:

***24/1000*** x ***4.8 minutes/year = 0.1152 mins/year.***

Now, assume that for any given call, there are at least 2 parties, and they each require a connection to a digital call processor: then the call processor failure rate (that could affect the call) is double the individual call processor failure rate:

***2*** x ***0.1152 minutes/year = 0.2304 minutes/year. (99.99996% availability)***

Traditionally, this failure rate is relatively insignificant with respect to other possible causes of outages (like processors, power supplies, fans, hard drives, etc). Thus, a digital board's reliability tends not be discussed since it is so rarely a problem. The low failure contribution rate applies to the other call processors that terminate end-points as well.

***Critical Sub-assemblies:*** These are equipment items that affect many users if they fail. In Avaya Communication Manager driven solutions, these items are designed to last a long time. Nevertheless, they will not actually last forever. It is therefore important to consider when reviewing your system configuration with your sales team, whether having some spares of these items on hand would be appropriate to shorten the MTTR time.

- Power supplies
- Fan assemblies
- Hard drives
- Transceivers
- IP Server Interface (IPSI)
- IP Media Resource 320
- ATM Interface
- C-LAN's
- Media Processors
- Other as appropriate

[18] Telcordia Technologies Generic Requirements, LSSGR: Reliability, Section 12, GR-512-CORE, issue 2, January 1998

## *Avaya Availability Analyses* [19]

# Avaya Availability Analysis
# Avaya S8300 Server and H.248 Gateways

(Avaya Communication Manager Software 3.x)

(based on data as of March. 30, 2006)

| Sub-System | Standard Reliability (for higher availability see footnotes [20] ) | | |
|---|---|---|---|
| | %Failure/year | MTBO (years) | Availability |
| Avaya S8300 Server | 11.8% | 8.5 | 99.994% |
| G150 Media Gateway | 14.3% | 7.0 | 99.993% |
| G250 Media Gateway | 13.5% | 7.4 | 99.993% |
| G350 Media Gateway | 11.8% | 8.5 | 99.994% |
| G430 Media Gateway | | | |
| G450 Media Gateway | 9% | 11 | 99.995% |
| G450 Media Gateway with Duplicate Power | 6% | 13 | 99.997% |
| G700 Media Gateway | 14.9% | 6.7 | 99.993% |

**Table 2**

[19] These are engineering estimates and are conservative; as field data is collected, the numbers will be updated. A Software allowance is included in the Availability numbers, in addition to the hardware contributions.

[20] For additional availability, (0.99995+), LSP is required to back-up Internal Call Controller; N+1 media gateways at each site; each IP endpoint homed to at least 2 systems run by Avaya Communication Manager Software (S8300, or otherwise).

# Avaya Availability Analysis
# Avaya S8400 Server
(Avaya Communication Manager Software 4.x)

| Sub-System | Standard Reliability | | |
|---|---|---|---|
| | % Failure/year | MTBO (years) | Availability |
| S8400 Processor | 6.57% | 15.2 | 99.997% |
| G650 Media Gateway | 13.1% | 9.0 | 99.994% |
| G650 Media Gateway with Duplicate Power | 6.13% | 16.3 | 99.997% |

* This analysis does NOT include availability of the customer's data networks, PSTN contributions, or contributions due to power outages. See further discussions below. A conservative hardware MTTR of 4 hours is assumed which includes technician travel and repair time.

**Table 3**

# Avaya Availability Analysis
# Avaya S85xx Server
(Avaya Communication Manager Software 3.x, 4.x)
(based on 2008)

| Sub-System | Standard Reliability | | |
|---|---|---|---|
| | %Failure/ year | MTBO (years) | Availability |
| S85xx Server Complex – Direct IPSI Connection [21] | 13.14% | 7.6 | 99.994% |
| S8510 Server Complex w Redundant Power Supply | 8% | 12.1 | 99.996% |
| G650 Media Gateway | 13.1% | 9.0 | 99.994% |
| G650 Media Gateway with Duplicate Power | 6.13% | 16.3 | 99.997% |
| H.248 Media Gateways | See Table 2 | | |

*** This** analysis does NOT include availability of the customer's data networks, PSTN contributions, or contributions due to power outages. A conservative hardware MTTR of 4 hours is assumed which includes technician travel and repair time.

**Table 4**

[21] Direct IPSI connection means there is no Ethernet switch between the Avaya Server and its Avaya Media Gateway. Thus, the failure rate of an Ethernet switch is not additive.

# Avaya Availability Analysis – S87xx

(Avaya Communication Manager Software 3.x, 4.x)
(based on 2008 data)

| Sub-System | Standard (or Duplex) Reliability | | | Higher Reliability | | |
|---|---|---|---|---|---|---|
| | %Failure / year | MTBO (years) | Availability | Failure/ year | MTBO (years) | Availability |
| S87xx Server Complex [22] | 11% | 9.1 | 99.995% | < 1% | > 91.3 | > 99.9995% |
| G650 Media Gateway - IP Connect - Simplex [23] | 13.1% | 9.0 | 99.994% | | | |
| G650 Media Gateway – duplicate IPSIs and power supplies [24] | | | | 1.86% | 53 | 99.9992% |
| G650 Media Gateway - duplicate IPSIs and power supplies and Media Processors [25] | | | | < 1% | > 91.3 | > 99.9995% |
| G650 Media Gateway - Fiber Connect [26] | | | | < 1% | > 91.3 | > 99.9995% |
| G600 Media Gateway | 13.1% | 9.0 | 99.994% | | | |
| H.248 Media Gateway | See Table 2 | | | See Table 2 | | |
| | | | | | | |
| * This analysis does NOT include availability of the customer's data networks, PSTN contributions, or contributions due to power outages. A conservative hardware MTTR of 4 hours is assumed which includes technician travel and repair time. | | | | | | |

**Table 5**

To attain high availability for large systems, the Avaya S87xx Server complex consists of two paired servers. One acts as the active server, and the other is the standby. To capture modifications of memory made on the active processor, and transfer them to the standby processor's memory, the servers contain a duplication module. With the hardware duplication memory writes are sent across a very high-speed fiber optic link for replication on the standby processor.

In Table 11 two configurations are shown for the S87xx servers. The High a Reliability configuration is designed with duplicated Servers, Ethernet Switches, and UPS. The Standard configuration is designed with duplicated Servers and UPS and a single Ethernet Switch.

[22] For higher reliability, the S87xx server complex is provided with duplicated servers, Ethernet switches (dedicated), and UPS's. The "standard" reliability configuration consists of duplicated servers and a UPS for each, with a single Ethernet switch (dedicated).

[23] IP Connect system – Simplex: single IPSI per PN, simplex Media Processor.

[24] IP Connect systems (dup'd IPSI's): duplicated IPSI's per PN.

[25] Duplicated IPSI and duplicated MedPro in active/stand-by configuration.

[26] Fiber-connect systems – Duplex: duplex IPSI's and EI's .

# Avaya Availability Analysis

## DEFINITY® Server R

(Avaya Communication Manager Software 2.x)
(based on data as of Aug.. 30, 2005)

| Sub-System | Standard Reliability (Single Processor Complex) | | | High Reliability (Duplicated Processor Complex) | | | Critical Reliability (Duplicated Processor Complex and ATM/CSS Switch) | | |
|---|---|---|---|---|---|---|---|---|---|
| | %Failure/ year | MTBO (years) | Availability | %Failure/ year | MTBO (years) | Availability | %Failure/ year | MTBO (years) | Availability |
| DEFINITY Server R Processor | 15.3% | 6.5 | 99.993% | < 1% | >91.3 | > 99.9995% | < 1% | > 91.3 | > 99.9995% |
| SCC1 or MCC1 Media Gateways | 15.3% | 6.5 | 99.993% | 7% | 15.2 | 99.997% | < 1% | > 91.3 | > 99.9995% |
| Center Stage Switch (CSS) Complex | 10.95% | 9.1 | 99.995% | 9% | 11.2 | 99.996% | < 1% | > 91.3 | > 99.9995% |

* This analysis does NOT include availability of the customer's data networks, PSTN contributions, or contributions due to power outages. A conservative hardware MTTR of 4 hours is assumed which includes technician travel and repair time.

**Table 6**

# Avaya Availability Analysis

## DEFINITY® Server SI

(Avaya Communication Manager Software 2.x)
(based on data as of Aug.. 30, 2005)

| Sub-System | Standard Reliability (single Processor Carrier) | | | High Reliability | | |
|---|---|---|---|---|---|---|
| | %Failure/ year | MTBO (years) | Availability | %Failure/ year | MTBO (years) | Availability |
| DEFINITY Server SI Processor | 21.9% | 4.6 | 99.99% | < 1% | > 91.3 | > 99.9995% |
| SCC1 or MCC1 Media Gateways | 15.3% | 6.5 | 99.993% | 7% | 15.2 | 99.997% |

* This analysis does NOT include availability of the customer's data networks, PSTN contributions, or contributions due to power outages. See further discussions below. A conservative hardware MTTR of 4 hours is assumed which includes technician travel and repair time.

**Table 7**

# Avaya Availability Analysis
## DEFINITY® Server CSI
(Avaya Communication Manager Software 2.x)
(based on data as of Aug.. 30, 2005)

| Sub-System | Standard Reliability | | |
|---|---|---|---|
| | %Failure/year | MTBO (years) | Availability |
| DEFINITY Server CSI Processor | 16.43% | 6.1 | 99.995% |
| CMC1 Media Gateway | 7% | 15.2 | 99.997% |

* This analysis does NOT include availability of the customer's data networks, PSTN contributions, or contributions due to power outages. A conservative hardware MTTR of 4 hours is assumed which includes technician travel and repair time.

**Table 8**

## Appendix B

## Assessment Methodology:

Failure modes play a significant role in system reliability modeling and requirements.  System reliability modeling involves identifying a system's failure modes.  Mathematical modes are then developed to predict the amount of time spent in those failure modes and the rate at which the system enters those failure modes (fails.)

Markov Chain Reliability Modeling is used as the mathematical model for predicting total system hardware availability. The advantage of this technique over others (for example, the *parts count* and *combinatorial* models) is its ability in capturing the fault-tolerant aspect of the platform.[27] [28]

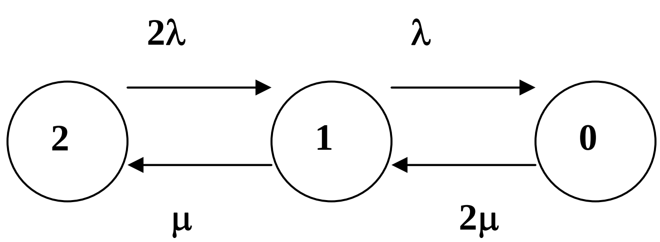
There are two parameters used for the mathematical modeling: individual-component failure rate and average outage duration experienced by end users. Full system availability is assessed by determining the contribution of subsystem failure rate and service outage duration. failure of core components such as the Avaya S8xxx Servers impacts all end users, and the downtime due to such failures is counted against the total system availability.  Subsystem failures, which impact a fraction of end users, are partial outages, and the outage duration is prorated in accordance with the percentage of end users to whom service was lost.[29]

### *Availability Predictions Given Individual MTBF and Failure Rates*

Availability of each subsystem is modeled based on a composite of its components.  For each component, MTBO is calculated as the reciprocal of estimated average failure rate (FIT [30]), and a conservative average repair time (MTTR) of 4 hours is assumed to account for technician travel time.  The following formula is used to measure availability of critical components.

A = MTBO / (MTBO+MTTR)

For components which work in parallel Markov State transition diagram is used.  For example for Avaya S87xx Server pair which work in active-standby mode, the following state-transition diagram is applied:




**State Transition Diagram for Redundant Components**

In Figure 1, state **2** represents both components (one in active mode and the other in standby) are operational, state **1** indicates only one is operating, and for state **0** both are in failure mode.  The system is operational in both states **1** and **2**.  The failure-arrival rate is associated with transitions from state **1** into state **0**.  The probability of such an event happening is given by:

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**27** Reibman, Andrew L. and Veeraraghavan, Malathi, Reliability Modeling: an Overview for System Designers, IEEE Computer, Vol 24, April 1991, pp 49-57.

**28** Boyd, Mark, *An Introduction to Markov Modeling:  Concepts & Uses*, Annual Reliability and Maintainability Symposium, Anaheim, California, January 1998.

**29** Such analysis and terminology is in accordance to Hardware Reliability Parameters, Section 4, and Outage Classification Categories, Section 7.1, Bellcore GR 512, 1995.

**30** Failure in Time (FIT).

## Appendix B (cont)

$$F = \lambda \times P_1$$

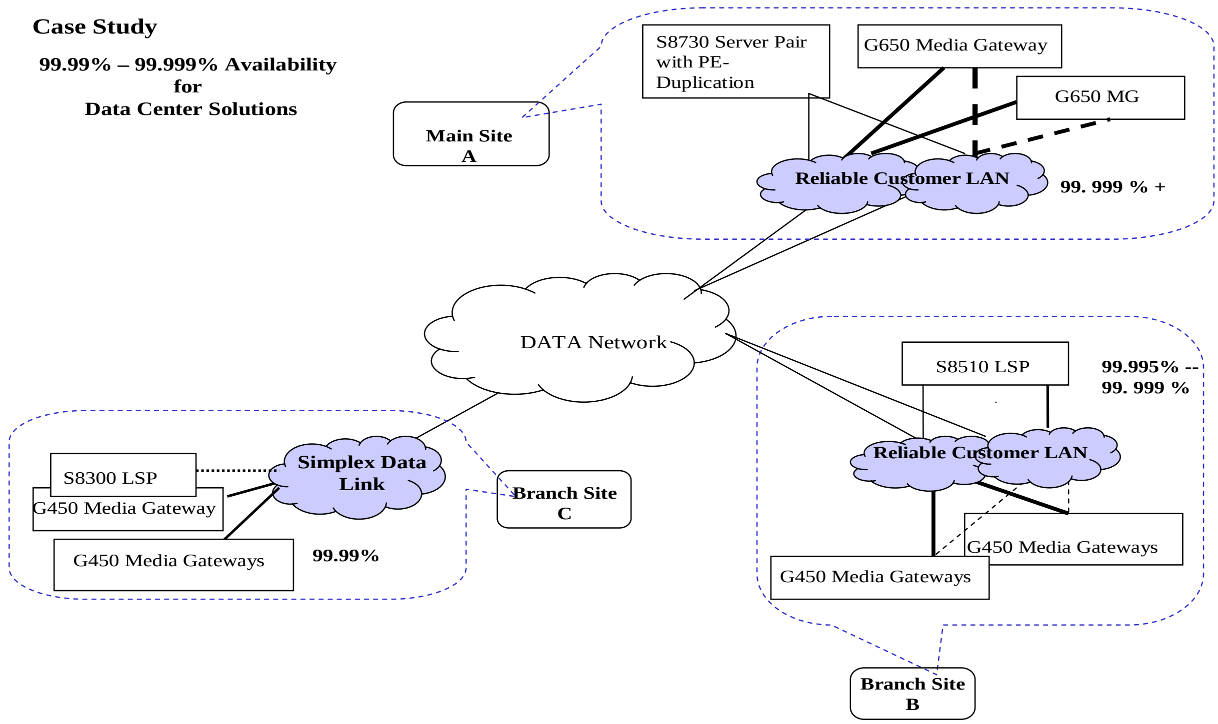
$$P_1 = \frac{2\lambda \times \mu}{\mu^2 + 2\lambda \times \mu + 2\lambda^2},$$

where $P_1$ is the probability of being in “state **1**”, $\lambda$ is single-component failure rate and $\mu$ is repair rate.[31]

## Appendix C

Examples of several Data Center solutions are presented in the following pages. Call processing availability highly depends on the configuration and the reliability of underlying data transport layer. In all cases with redundant data link, best network design practice is assumed. For availability calculation of the components MTTR of 4 hours for failure detection, response and repair time is assumed. For availability value of approaching 5 nines or better, there must be an alternative call control back up at the site or remote site. IP-endpoints must be administered to take advantage of alternative gatekeeper. Note that stable calls on IP-phones and H.248 Media Gateways will not drop during fail-over to an LSP. TTS enabled phones will not lose registration to the active server during short Control Network Outages.

[31] Markov Reliability Model normally assumes when in state 0, there will be 2μ repair time, which implies service is applied on both components simultaneously.




To achieve 99.99% or better: Separate signaling and media processing data link which can be routed to a duplicate WAN link. Note that modern techniques such as HSRP and VRRP allow you to dynamically re-route if a router (or WAN circuit) fails. Assure every IP endpoint has at least 2 valid gatekeeper addresses and do not depend on the same WAN link. When the branch connection to the Main site (active servers) is via simplex WAN link, must deploy a source of call control at the site (such as an LSP).

99.999% at the Branch can be achieved with highly reliable customer LAN (99.9995% +) and redundant connection to the DATA Network. Assure duplicated signaling and media processing links that will take advantage of duplicated (or back-up) WAN links. Assure every IP endpoint has valid alternative gatekeeper addresses in at least 2 network regions. Trunks to outside world must be engineered in N+1 redundancy and spread across the Media Gateways. Cluster of H.248 media gateways will provide N+1 DSP and Trunk resources.