Reliability
The ShoreTel Way
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1. Introduction

Reliability is a critical component of any business communication system. ShoreTel understands this and provides one of the most robust and reliable unified communications (UC) solutions in the world.

ShoreTel's architecture combines unprecedented reliability with a brilliantly simple design at a low total cost of ownership. ShoreTel designed a pure IP telephony solution from the start – instead of having to convert an existing TDM product to a hybrid (TDM and IP) solution. This approach gives ShoreTel built-in mechanisms that quickly and cost effectively route communications over a customer WAN and deliver the necessary enterprise-level reliability.

The ShoreTel UC system delivers industry-leading reliability that includes:

• A distributed architecture with an appliance approach for IP networks
• Multiple ShoreTel failover mechanisms which add resiliency and flexibility
• Centralized and/or distributed application services that fit any system architecture
• Comprehensive disaster recovery solutions that deliver enterprise caliber reliability
2. ShoreTel’s Distributed Architecture

The key component to ShoreTel’s philosophy is a distributed architecture. ShoreTel uses the mantra of “No single point of failure” as a guiding principle in its communication system design. This philosophy drives the design principles that ensure the communication system offers high availability because any system down time correlates to loss of money; through either loss of revenue directly or increased system and maintenance costs.

ShoreTel developed this highly differentiated architecture by combining the following features:

• N+1 redundancy instead of costly 1:1 redundancy
• A modular design that is superior to chassis, daughter boards or server designs
• High reliability components (flash media, RTOS, reduced number of components) that deliver a 60 year MTBF, which is approximately ten times higher than a typical PBX
• Robust survivability mechanisms (IP failover, dual LAN connections, power failure transfer, Contact center failover, trunk failover)

Figure 1 gives an example of a distributed architecture for a medium-size firm that has three office locations and some remote/traveling workers. Users connect to their primary switch but have the ability to fail-over to alternate switches and servers across the network as needed.

Figure 1. ShoreTel Distributed Architecture Unaffected by WAN Failure
The IP network allows the distributed users (phones) many ways to connect to the voice switch(es) and maintain business continuity.

### 2.1 N+1 Redundancy

Most IP PBXs are implemented with a central server (sometimes called a media gateway controller) that runs the call control to set up calls and provide telephony features. These systems use 1 to 1 (1:1) redundancy to provide 99.999 percent (five-nines) availability. In contrast, ShoreTel uses a distributed call control model based upon an appliance approach, in which each "voice switch" provides call control for a limited number of phones (and PSTN lines) while working seamlessly with other appliances to support system users.

A system is implemented by combining multiple voice switches that can provide full featured reliability throughout the network. By distributing the call control, voice switches can be made smaller, simpler and more reliable as each unit takes on only a portion of the overall task.

ShoreTel's unique, distributed architecture allows the "unit" of redundancy to be much smaller. A ShoreTel UC system can be made redundant by the addition of an incremental unit, rather than duplicating the entire system. This is called n+1 redundancy and allows the business decision maker to decide the level of reliability (and cost) of the communication system. The business manager simply adds the number (n) of extra voice switches that they want. Under normal operation, the load is spread across all units. When one unit fails, the load is redistributed across the remaining units. If the system is constructed with extra capacity, there will be enough capacity for all users, and no system degradation.

ShoreTel's n+1 redundancy is so much simpler and more cost-effective than the 1:1 redundancy used by other systems. For an n + 1 architecture, redundancy costs an extra 1/n. For a 1:1 architecture, redundancy costs 2n.

There are some additional benefits to the use of n+1 redundancy. Firstly, as there are multiple units, the system remains resilient even after a failure, as there are still n units remaining. The system degrades with each subsequent failure, but remains functioning for some users. Secondly, the units can be geographically distributed, making disaster recovery easier and redundancy much more cost effective for smaller, remote sites. This technology also protects against WAN failures. A third benefit is that the system can scale without a forklift upgrade simply by adding phone switches.
2.2 Highly Reliable Components

ShoreTel units have a single board construction with very few hardware components and moving pieces. For instance, the ShoreTel UC system uses small power supplies, does not use cables or connectors within the chassis, and requires only a few fan units. All of these attributes make the system very reliable and are a direct consequence of ShoreTel’s distributed architecture.

In contrast, other vendors still typically use either a separate server or PC, “classic” chassis-based unit, or a horizontal daughter board based design in their IP PBX systems. These designs have the following inherent weaknesses:

- The server/PC has numerous cables, connectors, circuit boards and large power supplies.
- The classic chassis contains a backplane, numerous connectors, large power supplies and fans in addition to the large number of components on each circuit board.
- The daughter-board design eliminates the backplane but may require adding cables, while retaining the connectors, and a number of components on each circuit board.

The main issue is that fans and large power supplies have a high probability of failure. The cables and connectors in these systems are frequently neglected in reliability computations, as it is difficult to assess mechanical reliability. But system administrators are familiar with having to re-seat cards and cables in these types of systems after moving them in order to get the equipment operating again. These are anecdotal observations, but reflect the actual problems of mechanical components in systems. Taking these reliability effects into account, along with the large component count in these configurations, their reliability is greatly reduced. Without redundancy, these systems typically deliver 99.9 percent (three-nines) availability rather than the target of 99.999 percent.

Flash memory is another differentiator for ShoreTel. By using this type of memory, we eliminate spinning media in the system. Spinning media has been shown to have a very short lifespan, on the order of two to three years, which dramatically decreases the mean time between failure (MTBF) of most systems. By contrast, ShoreTel systems deliver 60 years for an MTBF.

2.3 Remote Survivability

Remote survivability mechanisms are another significant part of system reliability. Any IP-based system that intends to support 99.999 percent reliability must support a capability to overcome the inherent unreliability of current IP networks. It is widely known that typical LAN and WAN network architectures are at best 99.9 percent reliable. Therefore, an IP communication system must address this unreliability with capabilities that overcome the weaknesses.
To accomplish this goal, ShoreTel systems implement the following survivability mechanisms:

- **IP Phone Failover**: Each ShoreTel IP phone maintains a heartbeat with its controlling IP phone switch. Should the unit become unavailable, the IP phone will automatically re-register with the system and be assigned to another IP phone switch.

- **IP phone switch Remote Failover**: Multisite n+1 IP phone switch availability can be achieved with a single extra unit at the headquarters site that can automatically cover for a failed IP phone switch at a remote site. Spare units do not have to be maintained at each remote site (as in required in the 1:1 redundancy model), which is a significant cost savings as the number of sites grows, reducing the cost of redundancy nearly in half.

- **Dual LAN connections**: Allows for diverse networking in the event of a LAN failure.

- **Backup Destination**: When call control finds that an endpoint is unreachable, it attempts to use a configurable “backup destination.” This ensures that calls do not ring forever or “go nowhere” due to failures or incorrect configuration.

- **Power Failure Transfer**: Power transfer fail-over allows for fail-over of an analog station to an analog trunk (usually ports 8 and 9) in the event that there is a power failure to the equipment.

- **Public Switched Telephone Network (PSTN) Failover**: If the WAN becomes unavailable, the system will dial out on a trunk to the destination PSTN Direct Inward Dial (DID) number to reach the remote site.

- **Failover Trunk Groups**: Each user is a member of a user group that can be configured with a prioritized list of trunk groups; with least-cost routing determining which trunk gets used in any given instance. A failover trunk group can be configured in the event of network or hardware failure. All IP phone switch models have trunk interfaces that can be used for fallback. A small number of analog trunks can also be used for fallback and provide PSTN connectivity when digital trunks become unavailable.

- **Contact Center Failover**: The ShoreTel Enterprise Contact Center runs in a hot standby configuration where the secondary server can be distributed across the WAN. Configuration and reporting data is synchronized actively to the standby servers and in case of server, network or WAN outages all agents supervisors automatically fail over to the standby server ensuring business continuity.

As mentioned earlier, LANs are less reliable primarily because they are implemented with multiple serially connected components. It is possible to achieve 99.999 percent availability on the network by using a redundant aggregation switch that provides redundant paths to the ShoreTel IP PBX; which is commonly deployed for large and midsized customers. Smaller customers tend to forego redundancy and rely on the inherent reliability of the equipment and a quick service call in case of an outage — content with a three-nines system and an expected downtime of eight hours a year.
Reliable WANs are the major challenge in networking, because unlike LANs, they are not under the control of the individual enterprise, nor even the individual network provider. WAN reliability numbers are not generally available, but our experience suggests that WAN links are available for basic connectivity 99 percent to 99.9 percent of the time, with voice quality availability perhaps as low as 98 percent. The best of breed network providers promise 99.99 percent availability when the WAN is implemented entirely by that single service provider. There are no known network providers with a 99.999 percent service guarantee.

When the WAN fails for IP-PBXs, the remote site loses contact with centralized call control – the single brain of the system. Phones at the remote site are placed in “survivable” mode and use a fallback call control located in the site’s gateway. This means that the remote site loses the benefit of the detailed call control rules and permissions contained only at the central call control location. Call routing at the “survivable site” loses higher business logic, call permissions, and restrictions, and often resorts to functionality comparable to nothing more than the equivalent of a basic home phone line. In addition, any higher level telephony applications and services are unavailable. This loss of features and functionality and fallback to “nothing but PSTN access” is often not acceptable for many businesses that rely on telephony features and applications to run their businesses.

The ShoreTel situation is entirely different in the case of WAN failure. There is no change in call control as the local phone switch provides call control for the site and continues to do so in the case of WAN failure. The call control in the phone switch maintains a cached copy of the database and business logic (see Figure 2). The database is maintained at headquarters and change notifications are sent to all ShoreTel phone switches in the system, while individual units update their database caches. The remote site acts as a fully functional, independent phone system when the WAN is down, and then transparently rejoins the main system when the WAN becomes available.

Figure 2. ShoreTel Distributed Call Control Unaffected by WAN Failure
2.4 Reliable Remote Office Applications

As mentioned in Section 2.3, when there is a WAN failure, IP communication systems must respond or else degradation/failure occurs. Besides the call-control requirements, there are application needs as well. The most critical of these applications at the remote site are: voicemail, auto attendant, hunt groups and in the case of ShoreTel, the desktop communication application ShoreTel Communicator. Remote ShoreTel Communicator solutions are addressed in Section 3.2.

ShoreTel responds brilliantly to this situation by offering the following features:

- Built-in voicemail for remote switches
- Back-up auto attendant capability
- Workgroup to Hunt Group failover
- ShoreTel Contact Center failover

For smaller sites, ShoreTel voice switches with integrated voicemail eliminate the need for a server. These are the “V” series switches – ShoreTel 50V, 90V, and 90BRIV (illustrated in Figure 3 below) which provide voicemail/auto-attendant and flash memory storage.

In the case of a WAN outage, the telephones will re-home to a redundant ShoreTel Voice Switch and voicemail/auto-attendant services will be provided by a server or V series switch. Voicemail messages for mailboxes on a different switch or server will be queued locally and forwarded upon connection restoration.

If call control cannot reach an application server, each ShoreTel phone switch provides a backup auto-attendant function to notify the user that the destination is unavailable and offers to connect the user to another number to provide call answering. The auto-attendant answers with a dial by number capability and the option to zero-out to the main menu.

The ShoreTel Workgroup is commonly used as an informal contact center. In the event that the Workgroup service fails, calls can be sent to a hunt group to ensure that the call is answered.
For ShoreTel Enterprise Contact Center, configuration and reporting data is synchronized actively to the standby servers. In the case of a server, network or WAN outage, all agents and/or supervisors automatically fail over to the standby server ensuring business continuity. Having standby servers ensures continuity in customer experience and minimizes any critical disruption to the support or revenue center.

3. Application Server Solutions

ShoreTel has the ability to provide centralized and distributed services. This is one of the areas that differentiates ShoreTel from the competition. With a single image system, all voice switches are aware of each other and the stations assigned to each switch. In this architecture, the management is centralized and services (such as voicemail) are typically centralized on a server, called the “Headquarters” (HQ). However, services like voicemail can also be distributed either on the telephone switches themselves or on other servers, call Distributed Voicemail Servers (DVS). The following sections discuss both centralized and distributed services.

3.1 Centralized Services

ShoreTel’s maintenance capabilities enable administrators to make major reconfigurations or upgrades and test them in as little as an hour. These same tasks typically take much longer on other IP phone systems, which lack ShoreTel’s simple ShoreTel Director single administrative interface, and must be administered by experts from an error-prone command-line interface. ShoreTel owes this distinction to its simple design and architecture.

Configuration changes are quick and easy because there is one single distributed system, regardless of the number of sites, and all changes—local or remote—are made from the ShoreTel Director console. ShoreTel Director is an Internet browser-based product that allows access to the ShoreTel equipment (voice switches, voicemail, auto-attendant, automatic call distributor, computer telephony applications and call detail records) from anywhere.

ShoreTel recommends implementing the system with multiple servers to avoid a single point of failure. The headquarters server can be backed up with an additional server, bringing the number of servers to n+1, modeling the n+1 availability model of the voice switches.

In the case of a server failure, the ShoreTel voice switch finds an alternative voicemail/auto-attendant server. The servers are arranged in a hierarchy maintained by the system administrator. When the voicemail/auto-attendant server assigned to a ShoreTel voice switch is unavailable, the voice switch analyzes its database until it finds a server and then uses it until its assigned voicemail/auto-attendant server becomes available.

Competitive systems typically require separate administration of each of the major components of the system, imposing a heavy administrative burden as illustrated in
Figure 4 below. On top of the complexity of a typical competitive multisite solution, all of the components at a remote site are a single point of failure, as 1:1 redundancy is too costly for small sites. The ShoreTel solution avoids these difficulties.

Note that there are 18 elements to configure: six per system/site. Voicemail and desktop integration are replicated in order to achieve reliable applications. To stitch the separate phone systems together, dial plan and call route tables must be separately configured for system to system calling or long distance calling, adding cost and complexity to the solution.

The Telephony Management Server (ShoreTel Director) coordinates the voice switches and application services on each server. The Telephony Management Server service notifies all the voice switches and services that are managed by this server of configuration changes and passes configuration data to them. Telephony application programming interfaces for server and desktop applications are also provided by the Telephony Management Server, allowing every application access to every phone. It also provides the “secret sauce” that ties all the phones, voice switches, servers and services together into a single image system.

### 3.2 Distributed Services

The ShoreTel approach to distributed services is to embed application services in its distributed architecture. A Distributed Voice Services (DVS) server can be located at each site. The system maintains its single administrative interface – ShoreTel Director, and unlike competitive solutions, does not require duplication. Each server duplicates call control, voicemail, and desktop integration (the server side of the desktop application, ShoreTel Communicator).
The ShoreTel architecture also allows additional instances of the configuration database to be installed within a system. This is typically implemented in a system with remote sites and a customer system that uses a DVS server. Changes made to the master database at the HQ location are automatically propagated to the remote sites. DVS servers can restart without requiring connectivity to the HQ location which eliminates the WAN as a functional and performance bottleneck.
4. Disaster Recovery Solutions

The ShoreTel system was designed for flexibility. In addition to the various options that ShoreTel can provide natively to customers, we have augmented our solution with solutions from third parties to deliver an unparalleled disaster recovery capability for the SMB and enterprise market.

4.1 Double-Take

ShoreTel decided to enhance its own highly reliable solution with a third-party product from Double-Take. Double-Take’s data replication technology combines continuous real-time backup and automatic failover capabilities for disaster recovery, high availability, and centralized backup. Double-Take goes beyond periodic backups to provide accessible and affordable data protection via data replication software. This ensures minimal data loss and enables immediate data recovery with failover from any disaster or system outage. Double-Take uses patented data replication and failover technology that continuously captures byte-level changes as they happen and replicates those changes to one or more target servers at any location, either locally or at a recovery site miles away.

The Double-Take solution provides the following benefits:

- Centralized reporting and analysis
- Flexible bandwidth scheduling
- High availability and failover
- Integrates with existing backup solutions
- Uses standard network protocols

The Double-Take solution has many useful features for an enterprise communication system, including:

- Continuous, asynchronous, byte-level replication
- Unlimited distance replication
- Hardware/application independent
- Certified Microsoft Windows compatibility
- Intelligent data compression
- Full voicemail redundancy as an option with DoubleTake

4.2 VMware

An alternative to Double-Take is VMware. The purpose of this solution is to allow customers to reduce their server footprint and therefore reduce costs by taking advantage of virtualization. Businesses can also leverage the high availability capability of VMware if they are looking for disaster recovery options.

In the ShoreTel solution, the system management (ShoreTel Director) software and headquarters software runs on the ESX hardware with version 4 software. Other ShoreTel solution components (telephony switches, ShoreTel Communicator, ShoreTel Call Center) run on their existing hardware components. ShoreTel software typically runs on a Microsoft Windows server operating system in a multiple VMware core environment.

A generic depiction of the VMware solution can be seen in Figure 6.

Figure 6. Generic VMware Solution for ShoreTel
This figure does not show every configuration possible as the actual customer implementation depends upon the number of users on the system, reliability requirements (none, cold standby, or hot standby), the data storage required, and other equipment factors.

The ShoreTel VMware solution offers the following options for customers:

**VMware support options**

- No reliability
- High Availability (HA) – this is a cold/warm restart with up to 3 minutes downtime
- vMotion – allows users to move a running virtual machine from one server to another in real-time with no degradation of user capability

**Mass Storage Configurations**

- Network Attached Storage – NAS
- Storage Area Network – SAN

Customers are free to mix and match the options based upon the size of the virtual machines and dimensioning trade-offs that they wish to make. Features like vMotion allow system administrators to perform maintenance during working hours without having to schedule system downtime which can have definite productivity improvements.

More information is available on VMware at [www.vmware.com](http://www.vmware.com).

### 4.3 Enterprise Contact Center Disaster Recovery

ShoreTel Enterprise Contact Center has a built-in disaster recovery solution that ensures that your most critical call center functionality is available 24x7. The contact center application can run in a hot standby mode with automatic failover capabilities. This ensures that the customer experience is retained during failure conditions and the call center continues to generate revenue or improve customer satisfaction.

ShoreTel advanced teleworker solutions also ensure that agents and supervisors continue to operate during network disruptions whether working at a remote site or teleworking from home. Agents can also login to the call center just by calling into an Interactive Voice Response (IVR) system if they lose their internet connection. Critical functions such as reporting is retained during any failure condition regardless of the location of the supervisor or the agent.
5. Summary

The ShoreTel UC system leads the industry in meeting the reliability and availability demands of businesses today. It combines powerful voice and UC features with a simple and easy-to-use management interface. This allows ShoreTel’s customers to focus on what’s truly important – managing the business, not managing a communication system.

ShoreTel customers have the flexibility to essentially create their own systems by choosing from the following needs:

- Distributed or centralized architecture
- The appropriate level of redundancy and cost
- The applications needed and the level of availability
- The level and type of disaster recovery needed

By giving the customer choices, they have the flexibility to tailor a ShoreTel UC system to suit their individual business needs.

For more information about ShoreTel products and solutions, please visit www.shoretel.com or call (800) 425-9385.