The First 90,000 Miles are Toll-Free

It's not E.T. phoning home—it's the shuttle astronauts of the National Aeronautics and Space Administration (NASA). And this call is private, two-way, and digital, more like the telephone call placed from a public phone booth on the Space Station of 2001: A Space Odyssey. *Life imitates art via a Cisco SoftPhone loaded onto an IBM ThinkPad 760XD so that eventually, astronauts can keep in touch with their loved ones during long voyages aboard the International Space Station (ISS).*

"The first time I ever saw someone making a private phone call from space in a movie was in *2001: A Space Odyssey.* And darned if we didn't meet that timeline. In the movie, that call cost $1.70. Our astronauts get the first 90,000 miles toll free."

—Brett Parrish, Television and Signal Processing Project Engineer, NASA, Johnson Space Center

Background

Despite rigorous training and preparation, one of the hardships of space travel is long-term separation from families and friends. For several years, NASA astronauts aboard space shuttles have been able to talk to their families via a specially modified, pre-H.323 video conferencing application, but families had to come into the Mission Control Center (MCC), located in Houston, Texas. And due to an antiquated satellite communications system, NASA was unable to move IP packets between orbiting shuttles and ground stations during missions.

A new, digital satellite interface called the Orbital Communications Adapter (OCA) changed that. While the shuttle has always had digital communication, its proprietary data streams could not carry commercial IP packets. OCA enables IP transport and off-the-shelf Ethernet devices for high-speed data transfers, and can also accommodate voice and video traffic. "The OCA project is updating the low-criticality communications capability on the shuttle and the space station, and in some cases moving capability ahead by thirty years. We couldn't use the really cool desktop applications that people take for granted now," says Brett Parrish, Television and Signal Processing Project Engineer at the NASA Johnson Space Center in Houston, Texas. "Astronauts couldn't do Web browsing or email from space."

Challenge

With bidirectional Ethernet communications in place, the astronauts could ask for a variety of new applications, including the ability to place private telephone calls to their families. "This is something a lot of astronauts have wanted for years, but it's never been a critical issue for space shuttle flights," says Parrish. "They train for years to go up there, but shuttle flights are anywhere from 7-14 days long. That's a camping trip. Every minute on a shuttle is timelined. They're trying to do the maximum amount of work in the least amount of time.

"But we're going into a whole new era now with the International Space Station, where astronauts spend three to six months on the station. They'll still have tight schedules, but they'll have time to sleep, watch the stars, and catch their breath. It changes from a two-week camping trip to really more of a sensory deprivation experiment when you go up there for a very, very long period of time. It's draining to be away from your kids for six months. But anything we can do to make life a little easier on them, we're looking into."

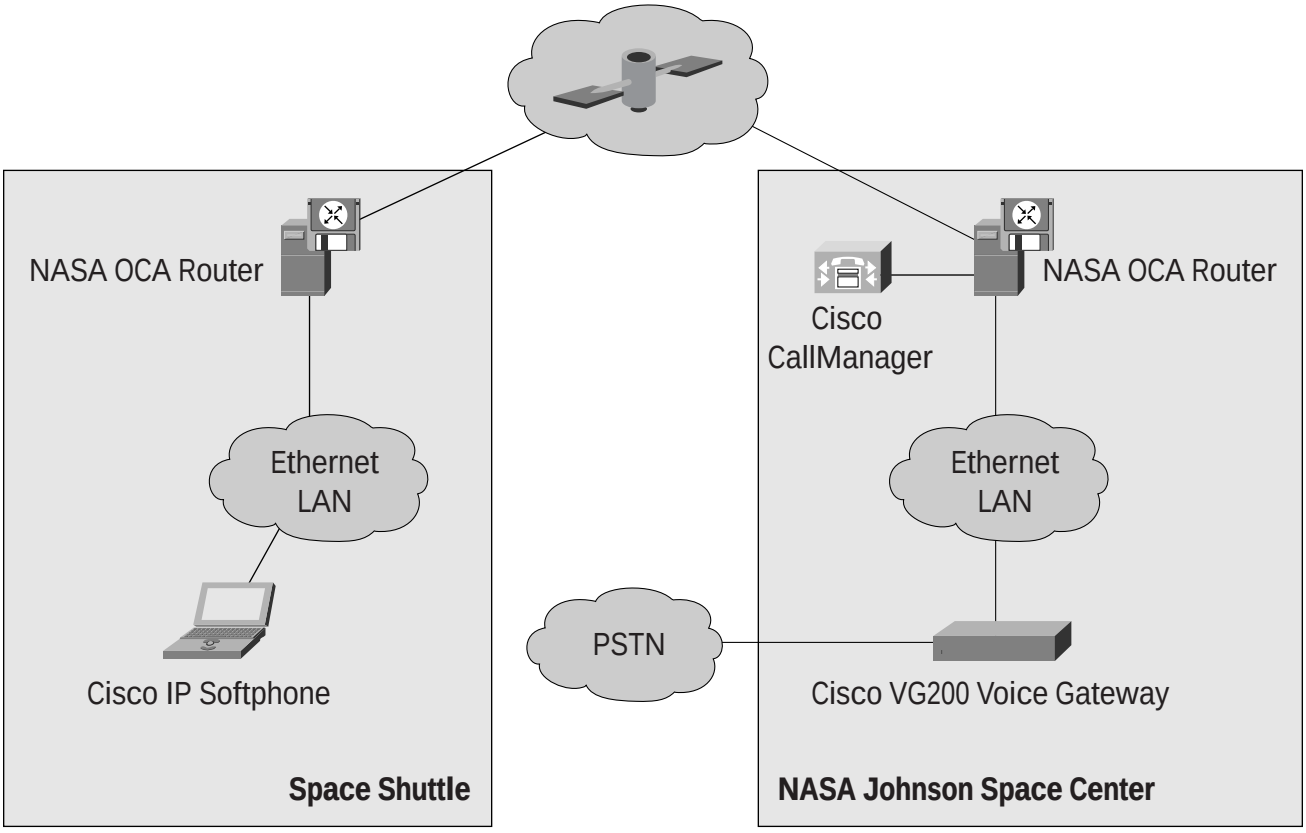
Parrish had been experimenting with Selsius and Cisco IP telephones for several years, and suggested using one aboard the shuttle and the ISS. However, adding hardware to a shuttle flight is a long process because NASA must consider the special environmental circumstances of space flight. Beyond simple weight-and-balance calculations, all approved equipment meets rigid standards for fire safety, electrical emissions, and so forth. Fortunately, Cisco has SoftPhone, which as a software product adds no weight and requires far less testing. Says Parrish, "There's a long process that engineering has to go through before we can fly something. Fortunately, in this case, the IBM ThinkPad 760XD laptops that carry SoftPhone have been flying for years. They're already certified."

The final challenge to getting IP telephones in flight is distance. Satellite signals travel between the orbiter and ground stations via two geosynchronous satellites and an intermediary ground hop for a total of 90,000 miles. "This may be the longest distance call that anyone's ever made," jokes Parrish. At the speed of light, that produces a minimum roundtrip delay of more than one second, which causes most interactive IP applications to time out.

Solution

Since the Cisco SoftPhone does not have hard coded timeouts, the Cisco engineering team modified it to meet the unique delay requirements of the OCA links. On board the shuttle or ISS, a 10BaseT Ethernet flight LAN includes the laptop with SoftPhone software and a Bose headset, and links to the satellite via an onboard OCA router. The signal travels across the private NASA Tracking and Data Relay Satellite System (TDRSS), which is fully shielded from any public network such as the Internet.

Figure 1 NASA Astronauts Phone Home from Orbit



On the ground, the Cisco Service and Support Solutions team assisted NASA technicians with building a separate LAN with a Cisco Call Manager, Cisco Voice Gateway 200 for PSTN access, a router, and Cisco 7960 IP telephones. Also, the Cisco Call Manager was modified to perform link recovery as the shuttle or ISS passes from one satellite link to another with blackout periods during their 90-minute orbit.

As of now, astronauts can direct-dial anybody in the world, but can only receive calls from NASA ground controllers on the Cisco 7960 IP Phones located in Mission Control. Long distance charges only apply to that portion of the call carried via the PSTN. Once the application is proven, NASA will link the system to the rest of its LAN. The system was tested and debugged from the ground before going into flight. Parrish and teammate Steve Schadelbauer orchestrated a series of rigorous tests, simulating delay, loss of signal, and bit error rates well above what is typical between MCC and an orbiting Shuttle.

Results

Astronaut Marsha S. Ivins placed the first-ever phone calls from space on February 10, 2001, just after 4 p.m. Central Standard Time. As a mission specialist aboard the orbiting Shuttle Atlantis, she placed the first call to the lead flight director, Bob Castle, in the MCC. The call was routed through the Cisco VG200 to the PBX to Castle's desk. The two had an animated conversation for several minutes. Soon after, Ivins' second call was placed to Parrish, who answered on a Cisco 7960 IP Phone. She asked him, "So how do you like getting the second-ever call from space?"

The first phone calls worked so well they were almost a non-event, according to witnesses. Ivins, Parrish, and Schadelbauer all commented on the clarity of call quality, pronouncing it better than audio quality of radio-based conversations with the Shuttle. With the successful trial, MCC can establish appropriate procedures for placing private phone calls from space.

"This is a pretty cool application, I've got to admit. There's a lot of excitement around here about it," says Parrish. The ability to make private telephone calls is very welcome to astronauts who will spend up to half a year at a time aboard the ISS. "After the first two weeks, you realize you're orbiting in a tin can and you're going to be there a long time. These guys have been trained for this, and they're psychologically ready, but they do have kids in school, and stockbrokers, and doctors, and people that they need to talk to. This will really help them do that.

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Corporate Headquarters
Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134-1706
USA
www.cisco.com
Tel: 408 526-4000
800 553-NETS (6387)
Fax: 408 526-4100

European Headquarters
Cisco Systems Europe
11, Rue Camille Desmoulins
92782 Issy-les- Moulineaux
Cedex 9
France
www-europe.cisco.com
Tel: 33 1 58 04 60 00
Fax: 33 1 58 04 61 00

Americas Headquarters
Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134-1706
USA
www.cisco.com
Tel: 408 526-7660
Fax: 408 527-0883

Asia Pacific Headquarters
Cisco Systems Australia, Pty., Ltd
Level 17, 99 Walker Street
North Sydney
NSW 2059 Australia
www.cisco.com
Tel: +61 2 8448 7100
Fax: +61 2 9957 4350

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