How Presence Can Enhance Connectivity and Collaboration

When most people hear the word "presence" in an IT or telecommunications context, they usually think of text-based instant messaging (IM), or *telepresence,* a term typically used to describe state-of-the-art videoconferencing. In this white paper, we'll introduce a much broader definition of presence, explore its evolution, and propose ways that presence can be used to influence the architecture and design of systems that support and enhance the ways we communicate and collaborate.

Defining Presence

Every device we encounter in our daily lives, from thermostat to washing machine to automobile, has increased in capability using embedded processing power and connectivity that would have been unthinkable 30 years ago. As the scope and impact of personal computers and mobile devices continues to expand into more of our personal and business lives, we must confront and harness this power directly.

Throughout history, technology has been used to increase the range and acuity of human senses, in response to basic limitations of the human sensory system in the face of curiosity about our universe. Human senses have evolved to respond to a range of inputs that are crucial for survival, but represent a small fraction of the information surrounding us. The spatial and temporal dimensions of this information are shown in Figure 1.

**Figure 1.**   Scope of Human Sensory Perception
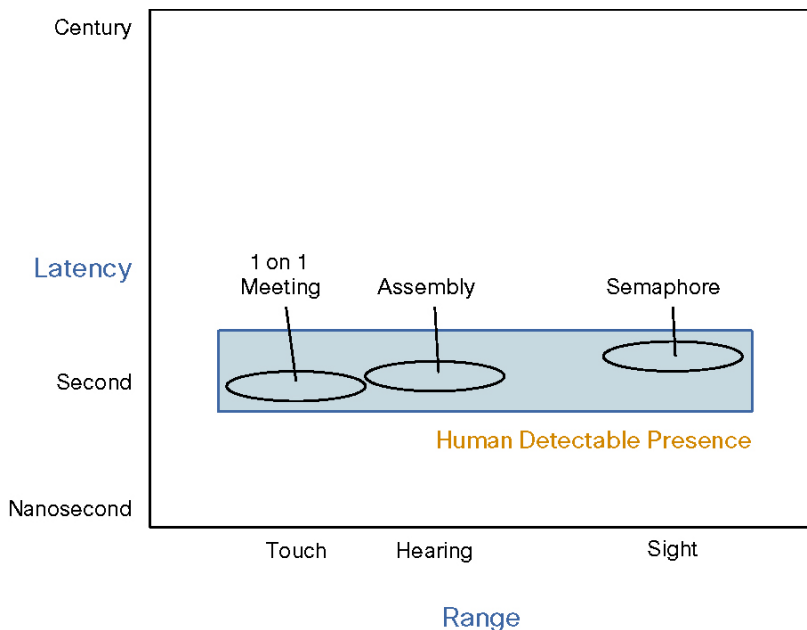
From an individual human spatial perspective, we can think about things that are within our grasp, within our hearing, and within our sight as "perceivable," but the amount of information we receive is subject to our ability to detect temporal changes in those things. For instance, we can't understand what is happening within a glacier simply by touching it or looking at it for a short period. Conversely, we can receive a tremendous amount of information about a person in a face-to-face meeting because the bounds of the information environment lay within our bounds of detection. (We ignore taste and smell in this discussion because, thankfully, mass market transducers for those do not yet exist.).

When we can observe and process information about an object, we say we have detected the *presence* of that object. We can also describe *types* of objects that share similar groups of characteristics. If we need to refer to a specific instance of a type, we can give it an additional *name*. If information transfer is bidirectional, we are *interacting* with the object. The average time between a transmission and a response is the *latency* of the communication. In this discussion we will focus on interactive communication, as opposed to one-way, or broadcast, transmission.

Because so much information lies outside of our perceptual range, we continually develop tools to change outlying information into a form that is perceivable. This is illustrated in Figure 2:

Figure 2.   The human "event horizon"
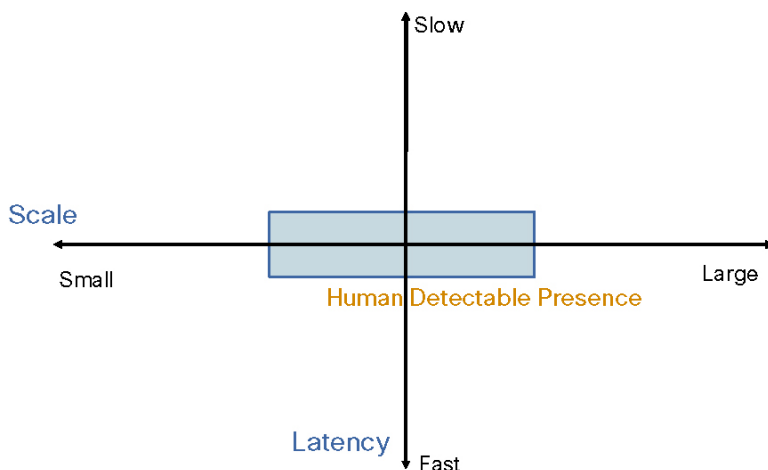
We can think of many examples of tools that make small things look bigger, big things look smaller, slow things faster, and fast things slower. A timely example is the ATLAS detector in the Large Hadron Collider at the European Organization for Nuclear Research (CERN). This device converts physical events that are extremely small and extremely fast into a form that human physicists can observe at their leisure. A major goal of telecommunications is to move information across the temporal and spatial boundaries of human perception, effectively expanding the range of our ability to detect and project human presence. As humans increasingly interact with non-human objects, our definition and understanding of presence needs to extend to those objects.

Early Days: Presence as Side Effect

Our first interactions over computer networks were simple. An endpoint was a terminal (perhaps with an acoustic coupler) at the end of a copper wire. A user was presumed to be "friendly" by virtue of physical access to the terminal. Users logged in to sessions and identified themselves with an ID, and perhaps a password. The computing system would assume that the person using a correct ID/password combination to begin a session was the owner of the ID/password combination, and therefore a legitimate user. A user's *presence* was defined by a valid login and the characters sent from the terminal. This was actually a step backwards.

In the days of Morse code telegraphy, a user's presence was defined not only by the characters transmitted, but also by the unique way in which the sender's hand moved the telegraph lever. This would result in a specific cadence and inflection to the code, called a *fist*. Telegraph receivers (and, later, radio operators) quickly learned to distinguish between multiple senders to the point where they could identify who was sending a message. Computer keyboards eliminated this authentication information channel for all but the most persistent intelligence agency personnel. Technology has only recently reached a low-enough cost where typing "fists" are being explored as an authentication mechanism.

From the beginning of telephony, authentication has been multidimensional. Early communications were typically point-to-point, and users identified themselves by name. If the connection was good enough, the user on the other end of the line could verify the caller's identity simply by voice recognition. Location was presumed to be where the physical phone lines terminated. But a caller did not know in advance that a call would reach the called party. If the called party was near the fixed telephone and chose to take the call, that user's presence was defined by participation from the static physical location.

Mobile phones changed that definition of presence by breaking the static relationship between session, identity, and location. This greatly increased authentication complexity, but human voice recognition remained a useful tool. Caller ID was intended to help identify an originating handset, not a person, and did not obviate voice recognition as an authentication tool. With cell-tower-based location services and GPS technology, mobile telephony presence now includes voice participation plus originating handset plus location information, but all of these can be spoofed. Biometrics are evolving to help at least authenticate the handset owner during a session. At the same time, voicemail has allowed users to treat telephone conversations as asynchronous; synchronized presence is not required for transmission.

While this evolution was occurring on the phone side, data communications networks were evolving from circuit-switched to packet-switched. This evolution didn't break static endpoints, but it did break static routing and also created weaknesses at multiple layers of the protocol stack. The definition of presence expanded to include the user's network address, and a route rather than a physical location. This, of course, could also be counterfeited. Security devices of various kinds emerged to help mitigate this and other authentication issues. On the data side, presence was still primarily indicated by text traffic.

Next emerged rich media: using the Internet to transmit bundles of bits representing still images, sound, and video. Many leading-edge industries jumped on this capability without worrying about reliability or security, while the rest of us waited for software and hardware vendors to provide mass-market tools for developers and users. The definition of presence initially expanded to include still images of users, and then moving images. Human visual processing is currently part of our authentication toolkit, but we expect that computing technology will advance to the point where counterfeit persons will emerge.

Users enthusiastically embraced both new voice and data networks. On the data side, developers were figuring out how to embed computing into previously "dumb" devices, resulting in smart devices that could work in and across networks. These devices could themselves be mobile or static, independent of their users. So the notion of presence expanded to include things and places, as well as people.

What the Future May Hold: A Detailed Scenario

Most computing and communications systems today use only part of the rich set of presence information that is presented or can be extracted from people, places, and things. What might we expect as these systems evolve?

Consider the following scenario:

The Morning Commute

When Lou woke up, he wasn't looking forward to the day. His project was behind, and the team had to figure out a way to get back on track. First, though, he had to get himself out of the house. Stumbling into the bathroom, he said "Check the overnights" to the medicine cabinet. His personalized information display showed up on the mirror with a summary of the past 12 hours' news stories, a list of his e-mail, and a weather forecast. No fires - good. He could shower and shave in peace.

Lou made it downstairs and grabbed some coffee. His wife and daughter had left early for a school event, and he found a note on the counter reminding him to feed the cats. "Find cats," he said. The screen on the refrigerator showed that Hazel was in the living room, but Bika was outside.

Ready to start the day, he said "I'm available" while he grabbed his phone, touched the screen with his thumb, and headed for the garage. As he moved toward the car, his phone automatically joined his car's vehicle-area network, authenticated itself, and unlocked the car. Lou got in, started the car, backed out of his garage, and headed for the office. As he drove away, the garage door closed automatically in response to his car's departure.

"Route to office," Lou said to the car, which showed him the best way factoring in traffic conditions. The Parkway was optimal today, and had the added bonus of decent scenery. Lou turned up the radio and hit the accelerator. About five minutes into the drive, he heard "Call from Cecil," which was great - Cecil was in the UK office and probably getting ready to leave, and Lou wanted to touch base. "Answer...Hey Cecil, what's up?" "Glad I got you, Lou. I know you're driving so I'll make this quick. The CEO of our partner is getting twitchy about the deal, and could really use some personal attention. Can you call him at his home tonight?" "Send me his contact info and I'll take care of it." "Thanks, Lou, I'm off to the pub for a bite."

Great, Lou wondered. What was the problem with the partner? Carolyn would know. "Find Carolyn." "Carolyn is mobile but unavailable." "Multipoint urgent to Carolyn: Please call me ASAP." That should get her attention, he thought. The car said "Rerouting due to accident." So much for the Parkway. Lou turned left and began following the alternate route.

Five minutes later: "Call from Carolyn." "Answer…Carolyn, thanks for getting back." "No problem, Lou, I saw your tweet. What do you need?" "Cecil just told me that Giles Bartlett is anxious about our project - what do you know?" "Just guessing, but the lawsuit in Texas was decided today. Maybe he's reacting to the verdict." "Hmm…can you put the judgment in our group space so we all can see it?" "Done." "Thanks."

Lou figured it would make sense to get the group's take on the Texas situation. "Call to Falcon team: Please read the Texas case judgment and let's put that first when we meet at 11 a.m." There was nothing more to do until he arrived, so he turned up the music.

At the Office

As Lou pulled into the garage, its parking space system knew that Level 1 was already full and sent Lou's car display a map of Level 2 showing the nearest empty space to the building. Lou parked the car and walked away hearing the "thump" of the electronic door locks as he left.

Walking up to the front door, Lou remembered to put his employee badge on. This was for visual indication only, as all access was controlled by his phone. Approaching the entry gate, his authenticated ID was sent from the phone to the entry station to log him in and let him pass.

As Lou got off the elevator on the fifth floor, he passed Mary, the administrator assigned to the floor. Mary served as the "arms and legs" for employees when physical documents had to be transmitted or received, and helped offload scheduling tasks when needed. She also served as the floor receptionist and office space manager. "Good morning, Mary," said Lou. "Hi Lou, you're in 502 today." "OK, I'm expecting a package. Let me know when you get it. And please give me a heads up when Cindy arrives at 10."

After grabbing a cup of coffee, Lou entered Room 502, where his cell phone detected the entry and began searching for devices in Room 502's office-area network to authenticate his arrival and enable Room 502 for "Lou in this office" use. It found the handset and thin-client workstation on the desk, the large format display on his wall, the HVAC connection, and the active partitions that comprised two walls of the office. All of these devices were awakened and put into "in office" mode using Lou's ID. Automatically, Lou's default screen configurations appeared on his displays, and the thermostat, phone, and wall glass were set to his presets. The name display outside the office changed from "Vacant" to his name. The embedded holographic projectors in the office credenza desktop displayed Lou's "virtual" personal effects, including a family photo, an old circuit board from a Cray 1, and a model of his old BMW 2002tii.

Lou checked the unified inbox on his workstation screen, happily noting that nothing urgent had developed since his conversation with Carolyn. That gave him time to prep for his 10 a.m. meeting with Cindy. The primary topic was her 6-month review. He opened Cindy's personnel file on the workstation screen, but then decided to read it in a more comfortable position. Dragging the document to an edge of the screen, several destination markers appeared, and he dropped the document onto the one marked "Pad." Lou opened the desk drawer and pulled out the workpad that now displayed the file, grabbed the pad and his coffee, and leaned back in his chair to read it.

A few minutes later, Lou heard Mary's soft chime from the office soundfield. "Answer. Yes, Mary?" "That package is here." "Great - I'll come pick it up in a few minutes." Lou turned back to reading Cindy's 360 review results. He barely noticed the time passing until the office soundfield chimed again, this time with a schedule reminder. "Details." "Cindy review meeting in 10 minutes." "Dismiss." Lou put the workpad down, and went to retrieve his package before Cindy arrived.

As Lou was returning to Room 502, his mobile phone rang with Mary's chime. Lou pushed the answer button. "Mary - is that Cindy?" "Yes." "Have her grab coffee and come to 502." "Right." Back in the office, Lou was moving his guest chair for the meeting as Cindy appeared at the door. "Hey, Cindy, thanks for coming. Have a seat." Lou said, "Office: Full privacy," and the window panes became translucent and all communications devices went into auto-answer mode. The dim recessed light ringing the ceiling changed from green to red, and "privacy" indicators appeared on all office screens.

Cindy's review was uneventful, except for a few questions she had about her 360 feedback. To help the discussion, Lou dragged the review data file from his workpad to the large-format display so the two of them could view it together. The meeting ended, Cindy left, and Lou touched the privacy indicator on his workstation screen, selecting "Full access." The ceiling indicator changed back to green, windows became transparent, and Lou began prepping for his 11 a.m. conference call with the Falcon team.

Lou put the workpad back in the drawer and scanned his inbox on the workstation display. Still nothing urgent. He opened the Falcon team shared space, found the Texas lawsuit decision, and saw Carolyn's annotation right where he expected it. He wanted to make sure that the entire team would be comfortable proceeding, so he was glad the topic was first on the agenda. Knowing he was working on the call, Lou dismissed the meeting reminder on the workstation.

At about 9:50 a.m., the office soundfield chimed for an incoming call. Glancing at the workstation screen, Lou saw it was Eric, one of the Falcon team members. Lou picked up the phone handset to answer the call. "Hey Eric, aren't you supposed to be on our call at 11?" "I'm in the building and I thought we could do it together. I see Mary put you in 502. Prime space - great view plus coffee and elevator proximity. Should I come up?" "That would be great."

When Eric entered Room 502, his phone joined the office-area network but, since Lou was the primary tenant, no office device settings were changed. The Falcon team included Lou, Eric, Carolyn, Uttam, Yvonne, and Barry. Carolyn was in a nearby facility. Uttam, Yvonne, and Barry were based in San Jose, but Barry was at a client site. As the system began to set up the conference call, it had to find all the participants and configure the display space to present to each one.

Barry was out of his office in a hotel with limited broadband access, so he'd be joining from his mobile device on 4G. Uttam and Yvonne were together in an office in San Jose, Lou and Eric were together in the home office, and Carolyn was in an office close by. The system enabled the large-format displays for Lou/Eric, Uttam/Yvonne, and Carolyn, and added Barry from his mobile device. Lou could see video of Uttam, Yvonne, and Carolyn on the screen, along with Barry's avatar, all composited around a virtual "table" space. The office soundfield was designed to make each speaker's voice appear to come from their "location" in the virtual space. As the participants joined the conference, their other displays and portable devices went into "unavailable" mode, interruptible only by urgent messages.

"Good morning, all," said Lou. "We'll try to get through this call as fast as possible. First off, have you all read the judge's decision from the Texas case?" Nods all around and an audible "yes" from Barry's avatar. "Carolyn, anything to add beyond your annotation?" "Well, let me just repeat that the decision cites extensive prior art, declares the patent invalid, and therefore makes infringement moot." Barry piped up, "What about an appeal?" "This was the last shot," said Carolyn. "We should be good to go." "Everyone agreed?" asked Lou. "Then we can move on to the production problems with our Chinese supplier. Uttam, what's the story?" Uttam dragged a schematic from his workstation to the shared virtual table space and began, "As you can all see, the primary clock signal is routed throughout the device…"

The team worked through the agenda items for the next half-hour, then ended the meeting. Everyone dropped off the call, leaving Lou and Eric in Room 502. "Any other questions, Eric?" asked Lou. "No. But you're going to call Bartlett and get him on board?" "Yup. As soon as you leave."

As Eric departed, Lou scanned the workstation display for any updates that required his attention before calling Bartlett. Seeing none, he picked up the office phone and said "Call Giles Bartlett." Giles had left permission with the network to find him at home, so the call was routed and rang simultaneously on his mobile and VoIP handsets. Giles grabbed the nearest one. "Hello, Giles? Lou here. Sorry to call you at home. Cecil tells me you were worried about moving ahead on the Falcon project." Giles expressed his concern about the Texas lawsuit. "We've just reviewed the decision, and it looks like we've got no infringement problems. And it looks like our manufacturing problems are behind us. Can I count on you to have your troops ready for the launch? Great. You owe me drinks at your club next time I'm in town. Bye."

Not a bad morning, Lou thought. Turning to his workstation, Lou checked out the day's lunch menu in the cafeteria. His face fell. Meatloaf, again…

Scenario Analysis and Discussion

As shown in the above scenario, we can expect communications technology to increasingly affect our personal and professional lives. Furthermore, we can expect a proliferation of devices as their costs decline - interaction will not be forced through a single device or interface because of cost. User interfaces will support multiple modes, depending on context. For example, expecting a person to find their glasses and begin typing might not be the best way to interact with a system first thing in the morning. It is much easier to say a voice command, "Check the overnights."

Note how presence plays a role - the system identifies the user (presumably by voice recognition) and assembles a fused display comprising several other system outputs, customized by our user at an earlier time. This information is presented in the most accessible location for the user - in this case, the medicine cabinet. The specific person (Lou) is making a request from a specific place (the bathroom) and the result is directed to a specific thing (the medicine cabinet integrated mirror/display). Rich presence information about all three enables a seamless user experience.

We can imagine that proximity sensors enable a microphone array in the bathroom to listen to user commands. But we might not want a microphone array in a personal space to be listening at all times. Systems that use presence information must be designed to reflect the important differences between *capability*, *mechanism*, and *policy*.

Voice recognition and authentication are examples of capabilities. Capabilities can be implemented by several different mechanisms, depending on environmental and budgetary constraints. Mechanisms are used based on a policy that is described either by users, system developers, or a third party (e.g., a regulatory body). Getting the pieces right is hard - a policy that says "never turn on bedroom microphones when the lights are off" could cause a fire-related death unless an alarm could be triggered using another mechanism. Generally, the hardest part of the capability/mechanism/policy trio to get right is policy.

As we see in the scenario, presence can have multiple aspects: *temporal*, *spatial*, *modal*, and *social*. Temporal presence describes behavior in time - is the presence constant or variable? Is variable presence of a fixed duration?

This information constrains the capabilities, mechanisms, and policies that can apply to an object (human or otherwise) in a system. Similarly, spatial presence describes behavior in space - what is the range of the object, a building, or a planet? How quickly can it move? Modal presence describes how a user or object presents its presence information to another user or system: Is there an avatar? Is it a still or moving image? Or, is just a binary value required signifying a specific location and time? We can also think about the network of relationships between multiple objects. Borrowing from current usage, we can call this aspect of presence social: Can this object be in a group? What is the visibility of the object to other groups?

Presence As Architectural Driver

Figure 3 combines the general architectural concepts of *capability*, *mechanism*, and *policy* with the *temporal*, *spatial*, *modal*, and *social* aspects of presence to illustrate how their interaction can inform the architecture of presence-enabled systems. Note the entries at the intersections are merely examples that are derived from system requirements. Good system designers will add interface specifications between the intersections to minimize the impact of changes at them.

Figure 3.   Presence Function Space

	Capability	Mechanism	Policy
Temporal	Asynchrony	Store-and-forward	Default to voicemail
Spatial	Global Geotagging	GPS	Can hide
Modal	Still image avatar	JPEG2000	Default to shadow
Social	Work group	Directory service	Always visible to manager

Returning to the scenario, a policy that enables the kitchen microphones allows the house system to recognize the "find cats" command and generates a query to a pet location system, displaying the result on the refrigerator. In this case, policy exists in multiple systems, but the policies governing the pet location system are not pet-defined (readers with cats will appreciate that they would probably prefer otherwise. Even if it were so, cats would likely argue that mice should not be able to access the cat location system). This is also a simple case - policies that span multiple systems or interact are harder to specify, test, and verify, and user-definable policy in multiple cooperating systems is harder still. This complexity is a challenge to be met by future presence-based systems.

Cooperating, networked systems are assumed as the user moves to the car in the garage. Lou's "I'm available" command is detected by the kitchen mics just before he authenticated the phone with his thumb. This action is most likely only a part of the authentication policy/mechanism chain. It is likely that the system would also be monitoring user behavior, comparing it to historical patterns to detect variances that would require stronger authentication from the user. Once authenticated, Lou's availability information is distributed through the communications network. When Lou enters the limited range of the wireless vehicle network, his authenticated phone joins the network and executes the policies that govern unlocking the car and preparing it for Lou's use. The scenario describes unlocking the car doors, but biometric information might also be sent to the car to adjust the seats and mirrors, set suspension preferences, and pretune the radio.

During the drive to work, Lou hears the "call from Cecil" announcement because he previously made himself available. Otherwise, the call would have been routed to voicemail or some other text-based channel. An interesting policy/mechanism question is how to enforce hands-free operation for a driver when a vehicle is in motion, while allowing passengers to use handsets. Readers considering a solution will quickly appreciate its non-triviality, and its dependence on multiple systems and rich presence information.

Hands-free operation is also presumed as Lou attempts to contact Carolyn. In the example, the system sees Carolyn as "unavailable." This could be for explicit reasons (e.g., she doesn't want to be disturbed during her yoga class) or for implicit reasons (e.g., her moving vehicle was in a tunnel). Lou's "multipoint urgent" direction to the system causes a message, marked urgent, to be sent to all of Carolyn's known routes. She happens to see the one on Twitter, and calls Lou in response. The system knows Lou is in the car, and routes her call to his mobile phone. A truly intelligent system would know the history leading to Carolyn's call, and automatically delete the redundant messages from Lou in her other channels' inboxes.

Lou's command "call to Falcon team" has a slightly different syntax than his previous call. This variability will be embraced in future systems to make user interaction fluid and expansive. "Falcon team" in this example expands to a distribution list of addresses and, since not marked "multipoint" or "urgent," Lou's message is sent only to each recipient's primary address in an appropriate format.

Parking the car at work is made easier using presence-based interaction between Lou's car and a "smart" garage, which has been instrumented to know when spaces are occupied. The example describes a simple policy of first-come, first-served allocation, but we could imagine more complicated policies that gave preference to visitors or executives. Lou's car is locked when its vehicle-area network determines that he has left the car - an example of system behavior changing in response to absence, the inverse of presence.

As Lou makes his way into the building and up to the fifth floor, he encounters Mary, who informs him of his office assignment for the day. We might ask why, if there is so much presence information in this system, an office is not automatically assigned to Lou? The answer is hinted at in Eric's comments to Lou about Room 502: "prime space - great view plus key coffee and elevator proximity." This office has attributes that many potential occupants might find desirable. A simple automated policy of first-come, first-served might allow an individual to obtain repeated assignments to this office based on commute time, which could be seen as inequitable to those in far-flung suburbs. Any other algorithmic policy would quickly become unwieldy as implementers attempted to shoehorn in every combination of employee concerns. The result would likely be unpopular with all. Instead, letting Mary assign offices based on user requirements and her own judgment allows a much more flexible mapping of people to offices, and also allows the occasional unhappy employees to address their issues directly with Mary. Sometimes automation is not the best way to implement policy. Good designers know, especially with humans in the mix, that just because you can automate doesn't mean you should.

Room 502 is one vision of a future office that acknowledges the increasing demand for flexibility in housing a workforce. Lou's ID and biometric information are used to configure all of the devices in the office, as well as the office itself. In this admittedly extreme case, no physical effects are allowed to personalize Lou's working space. Instead, digital 2D and 3D images are projected so they are visible to visitors during Lou's use of the office. One might imagine that in this future, status is indicated by the presence of "physical" personal effects in an office (implying that it is not shared).

On the other hand, Room 502 does feature a collection of displays and input devices that allow a variety of system interaction and work styles, instead of forcing Lou to depend on one interface. All of these are seamlessly connected into a single virtual workspace. The office is fitted with a microphone and speaker array that allows speech and sounds to be located and placed in a 3D soundfield. Answering a phone call in the office can be hands-free, as in the car, or hands-on for privacy, at Lou's discretion.

When Lou leaves Room 502 to get coffee before his meeting with Mary, his departure is noted by the system, so that when Mary calls him to announce Cindy's arrival, the call is routed to Lou's mobile phone. His office number automatically becomes primary when he returns. When Cindy arrives, Lou's command for "full privacy" not only intercepts calls, but disables the office microphone array. Multiple status indicators provide feedback for this important function. After the meeting with Cindy, Lou has to physically re-enable the offices mics, which he does at the workstation.

The Falcon team conference call demonstrates a system's use of location aspects of presence to emulate a meeting environment using multiple sensory input and output cues. Though Lou and Eric will move their chairs so they are within range of the single-wall camera, the office microphone array will be able to place their voices at different locations for other conference participants; likewise for Uttam and Yvonne. This additional spatial cue contributes to higher conference "fidelity" in the same way that higher-bandwidth audio was used to offset the negative perception of lower-quality video in early videoconference systems. Barry's lack of a high-bandwidth connection due to his location causes the system to create an image that is appropriate for his mobile device. Real-time audio and video processing is used to blend multiple inputs into a single meeting display, rather than disjoint split screens. The virtual "table space" is used to share objects, but nothing would preclude a user at an endpoint from grabbing the object and dragging a copy to another display for more detailed inspection.

During the conference, all non-conference devices go into "unavailable" mode. Here is an example of policy attempting to enforce civil behavior. This is probably less disruptive than asking participants to place their mobile devices in a box before starting a meeting, but that can work too.

Lastly, Lou wraps up with Eric and calls Giles, relying on presence information in the system to find Giles at the appropriate location and device.

Implications for Designers and Implementers

As the preceding example demonstrates, effective use of presence in automated systems is proportional to its pervasiveness not only within a single system, but also across cooperating systems. Standards like Extensible Messaging and Presence Protocol (XMPP), a streaming XML protocol specification, have emerged to address part of the solution.

Protocols are a good starting point for implementing presence capabilities, but efficient development and deployment of systems incorporating rich presence will depend on encapsulating such standards into shareable, loosely coupled resources. The architectural evolution from internal program object to shared library object to IPC-based function to network-based service is well understood in other areas, and there is no reason to expect that presence will be an exception.

Likewise, there are historical market precedents for seemingly standalone capabilities migrating into functional clusters, and then being absorbed into an operating system. The marketplace will determine whether or not presence services are packaged as "middleware" before ultimately being absorbed into an OS.

Recognizing the likely evolutionary arc of presence technology, forward-thinking applications builders should aim to create appropriate abstraction layers that minimize rework as this evolution progresses.

Summary and Conclusion

The combination of multiple information channels, multiple devices, rich presence information, and robust authentication allows us to imagine cooperating systems that enable rich communications by supporting a wide range of capabilities, mechanisms, and policies. Smart design should not force a user to be aware of these details. Large systems are likely to employ network-based services to manage presence information, delivering easily accessible power that will be a distinguishing characteristic of market-leading communications products and services in the 21st century.