Shoal

CREATING COMMUNICATION TECHNOLOGY FOR RADIOLOGY 2.0

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EXECUTIVE SUMMARY

Radiologists collaborate and communicate with a variety of stakeholders and experience a large number of interruptions over the course of a day.

The communication network of a radiologist depends on a combination of landlines, pagers, cell phones, email, and multiple other systems. To help radiologists prioritize and manage daily interactions, GE Healthcare asked a team of Masters students from Carnegie Mellon University's Human-Computer Interaction Institute to design a collaboration and communication solution for Radiology 2.0.

Our research underwent two phases. In the Discovery phase, we gathered data from 27 participants in 5 hospital locations using interviews and shadowing. Participants included diagnostic and interventional radiologists, technologists, referring physicians, information technology staff, and administrative personnel.

In the Synthesis phase, we reorganized the data to extract breakdowns, insights, and design ideas. Using the data we collected, we created data models to better understand radiology workflows. We transcribed interviews and observations and organized these in a spreadsheet to discover common experiences and perceptions. Then, we used affinity diagrams to cluster our findings and reveal underlying themes.

RESEARCH FINDINGS

Turn to pg 32 - 63 for details.

1. Teamwork is undervalued: While radiologists are given tools and encouragement to be productive as individuals, they rely heavily on teamwork to maximize productivity and to remove stumbling blocks. A large part of the radiologist's work is communicating with various people across departments. Design systems that support and encourage teamwork at collaborators' mutual convenience.

2. Systems fail to account for presence and mobility: Most existing designs fail to account for the mobility of physicians. There is no good way to locate and communicate people when you need them. Create solutions that facilitate effective communication in consideration of mobility.

3. Interruptions create desire for prioritization: Differentiating between useful and unimportant communication is the hard part. Radiologists seek to prioritize certain types of interruptions and deal with them at their own pace. Provide mechanisms to help radiologists rank incoming communications.

4. Low system reliability wastes time and causes frustration: Although the reliability of systems and patient data greatly impacts productivity and quality of care, radiologists report that providers are not paying to upgrade entire systems. Shift focus from full-scale system overhauls to improving existing designs, reducing inconsistencies and improving performance.

These findings shaped our vision for possible prototypes. Design guidelines are suggested to GE Healthcare based on field observations by Shoal.

For more on our visions, please turn to page 64.

Design Guidelines

1. Design systems that support and encourage teamwork at collaborators' mutual convenience

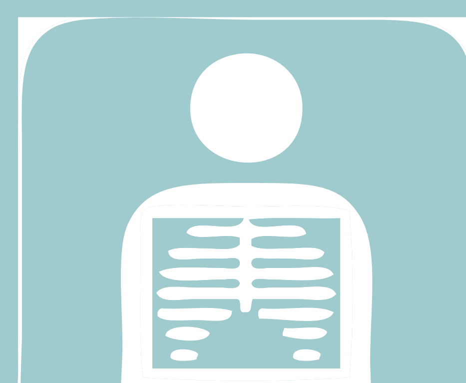
2. Create solutions that facilitate effective communication in consideration of mobility

3. Provide mechanisms to help radiologists rank incoming communications

4. Shift focus from full-scale system overhauls to improving existing designs, reducing inconsistencies and improving performance

HUNT STATEMENT

Understand communication-management techniques in radiological settings in order to design an integrated, collaborative interface that streamlines workflow and increases productivity among stakeholders.



BACKGROUND

INTRODUCTION

"We're a big innovator in healthcare and technology.... I know that in my lifetime we can treat major diseases, like cancer, more effectively at lower cost."

– Jeff Immelt, GE CEO

Radiology 2.0 is heralded by GE Healthcare as the next generation platform for radiology product offerings. The preexisting platform contains several digital solutions that helped to convert the world of radiology from its origins in film and paper. These digital solutions enable radiologists to read images and distribute work more quickly while providing a more seamless connection between the reading room and imaging technology. However, at the same time, radiologists frequently experience collaboration and communication breakdowns that existing digital solutions leave partially or fully unaddressed.

In January 2012, GE Healthcare asked a team of Masters students from Carnegie Mellon University's Human-Computer Interaction Institute to design a proof of concept for a Radiology 2.0 collaboration and communication management tool. In previous years, GE Healthcare contracted student teams to design improvements to its Picture Archiving and Communication System. Many teams incidentally observed and reported interruptions as a critical issue affecting radiologists' productivity.

Radiologists collaborate and communicate with a variety of stakeholders. Some of these are referring physicians, technologists, nurses, medical assistants, administrators, support personnel, and information technology representatives.

Radiologists place highest priority on interruptions by referring physicians to discuss critical results, but attitudes differ toward other workflow interruptions. Some look forward to surprises while others dislike distraction. With the increasing combination of landlines, pagers, email, cell phones, personal laptops, iPods, and radiologist information systems, workflow is simultaneously streamlined and fragmented.

In truth, there is no universal radiologist. On the surface, radiologists are unified by common activities such as protocoling patient scans, reading images, dictating and reporting findings. But beneath these resemblances, radiologists play diverse roles such as specialist, surgeon, resident, attending, nighthawk, staff president, and private practitioner. As a result, workstations and existing communications systems differ by individual, department and healthcare provider.

Designing successful collaboration and communication solutions for the entire population of radiologists requires taking all of these differences into careful consideration.

KICK-OFF MEETING

Team Shoal and GE Healthcare discuss productivity and role diversity after meeting and sharing presentations

We invited our project mentors from GE Healthcare to a kick-off meeting in Pittsburgh to launch our collaboration. Our mentors presented an overview of current radiology workflows and systems. We followed this with a proposed project timeline and a description of our research and design methodologies.

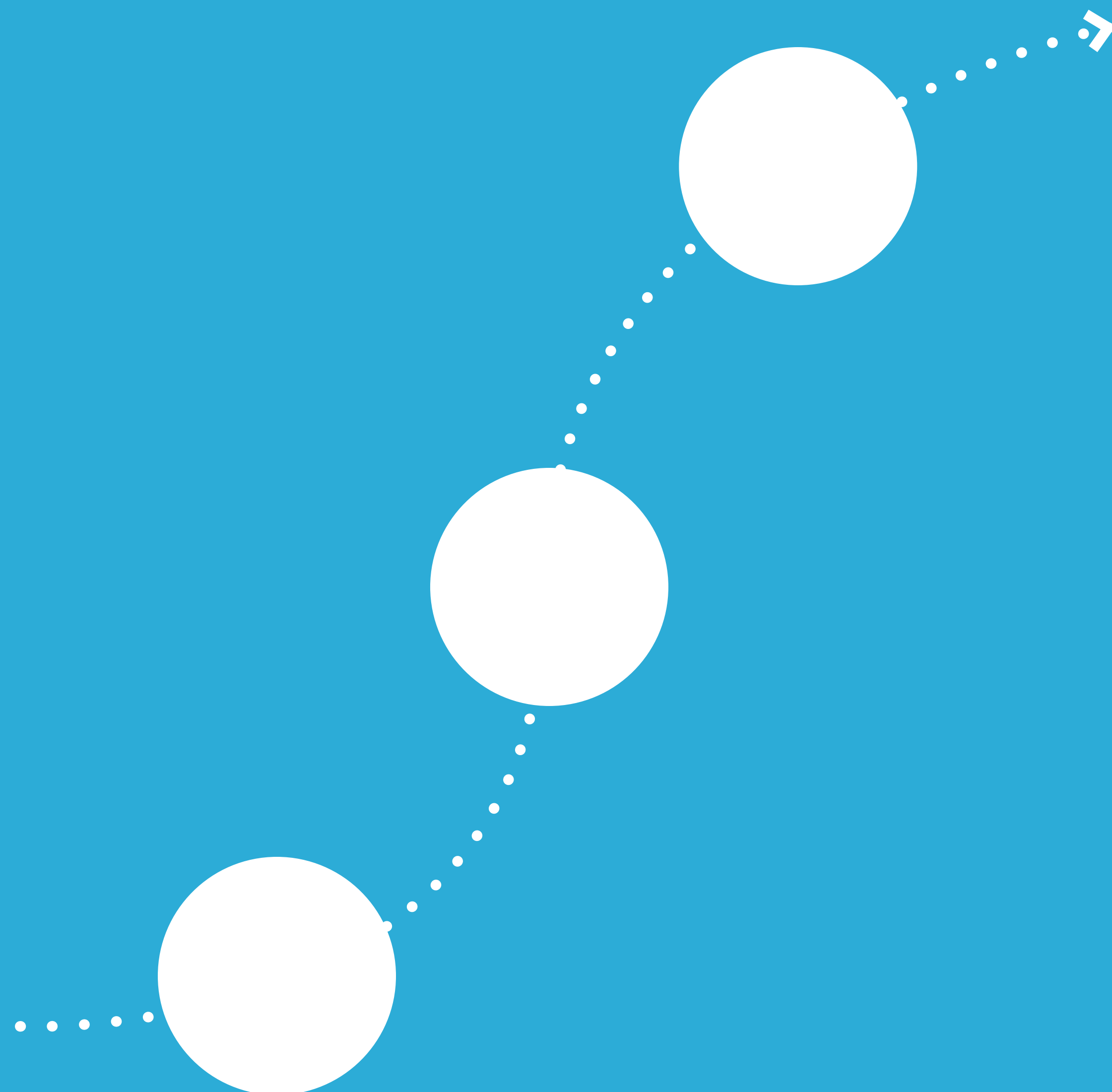
Our proposed brainstorming workshop quickly transformed into a full-fledged white-boarding session with our mentors leading the way. Trading our Post-its for a set of dry-erase markers, we spent several hours discussing roles and collaborations, existing breakdowns in workflow, and the effects of oversight and regulation.

Our mentors' wide-ranging experience in product development, user experience, and technical feasibility resulted in an unexpectedly deep and detailed conversation. We learned about the surprising diversity of roles in radiology, and our mentors alerted us to preconceptions our research would soon challenge about which roles generally communicate with one another and with what frequency.

To maximize the value of our meeting, we documented our combined notes and diagrams for review the following morning. Our mentors also sent us their presentation slides and some recent competitive analysis data. We used the experience and materials acquired in our kick-off meeting to better familiarize ourselves with the scope for which we planned to design.

GE Healthcare describes the web of systems today's radiology stakeholders use to communicate

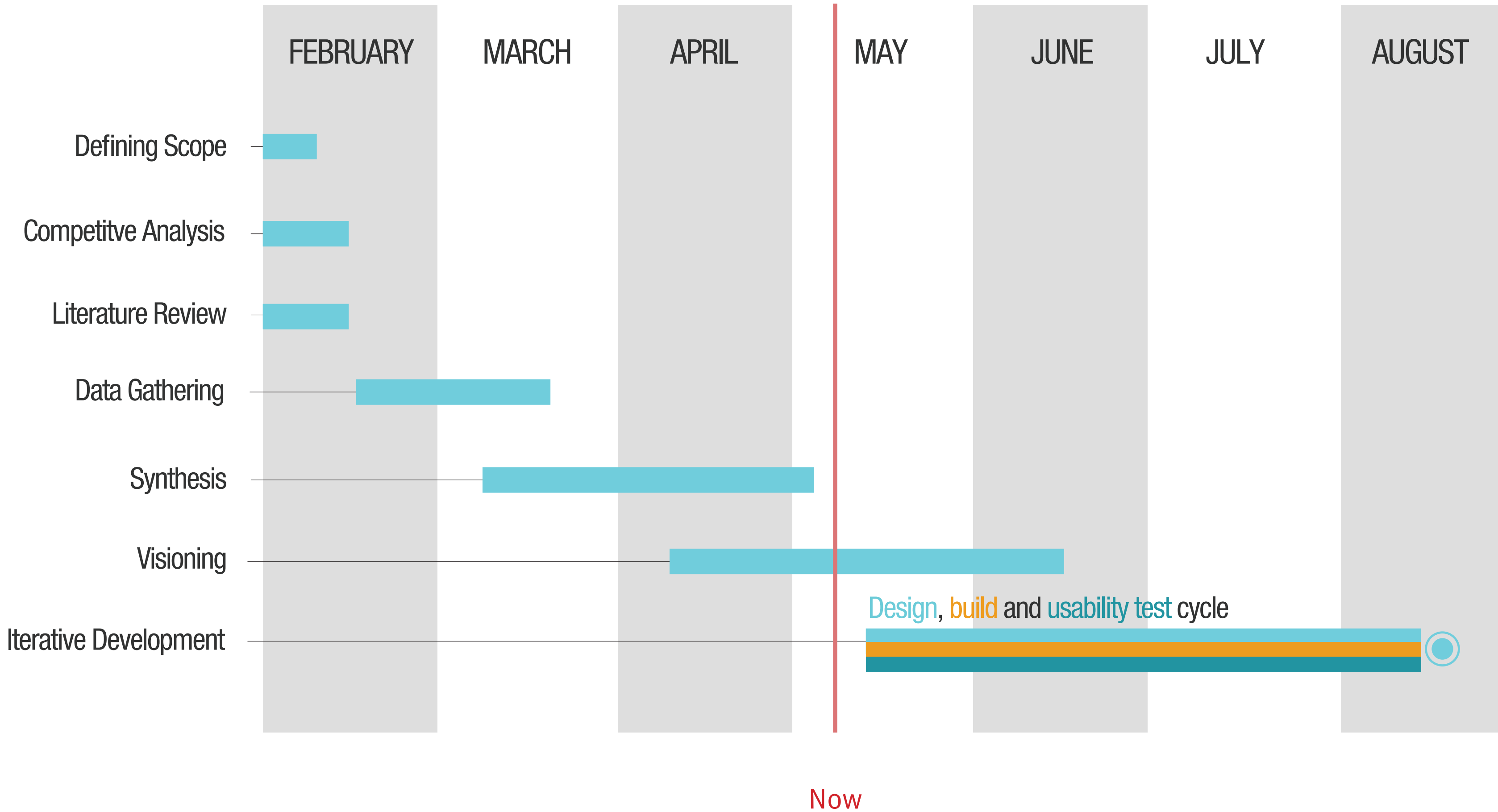
PROCESS



OVERVIEW

After improving our understanding of the problem area by conducting a literature review and competitive analysis, we developed a research plan with logistical assistance by GE Healthcare.

Our research underwent two phases. In the Discovery phase, we gathered data in the hospital setting by using contextual inquiry methods: interviews and shadowing. In the Synthesis phase, we reorganized the data to extract breakdowns, insights about the roles and interactions we studied, and design ideas for consideration during our forthcoming Design phase.

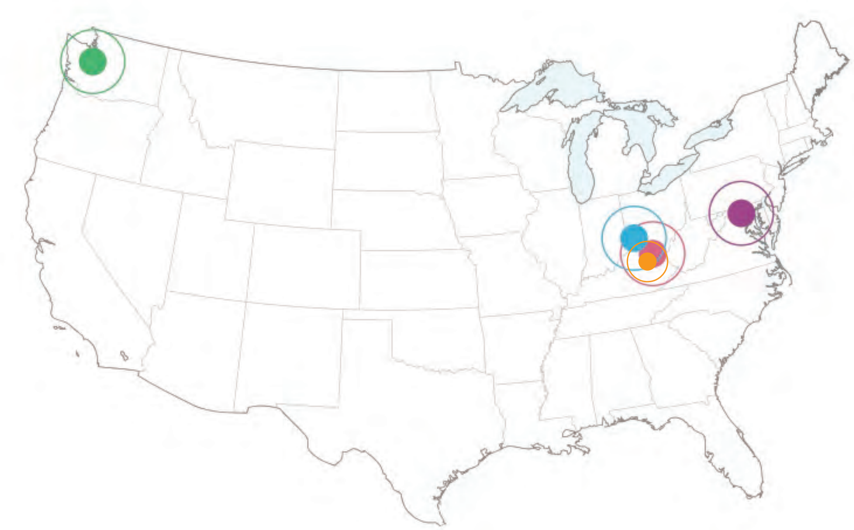


PARTICIPANTS

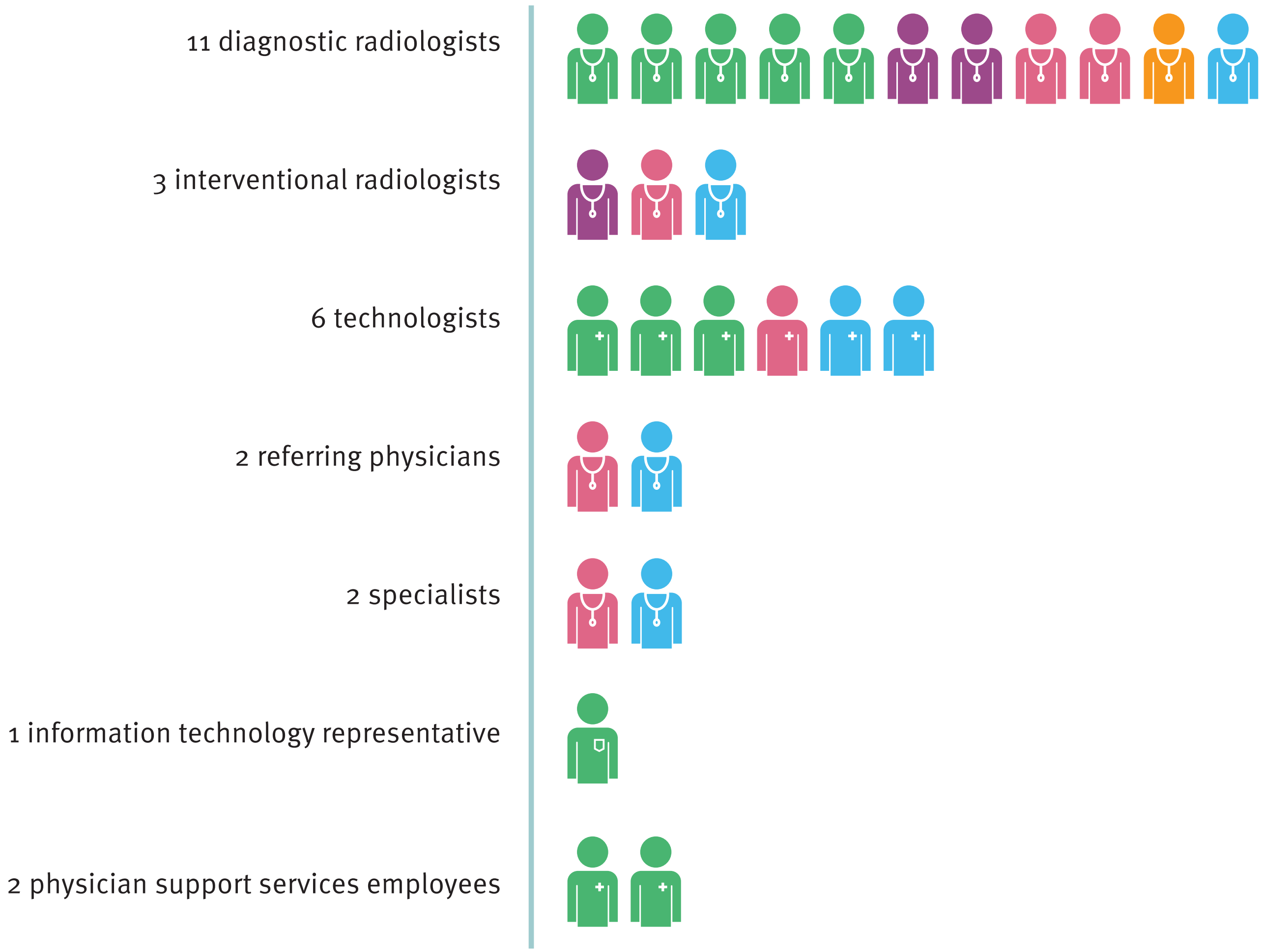
GE Healthcare arranged for our visits to five hospital locations. We conducted 27 extensive interview-shadowing sessions, formally known as contextual inquiries, with participants in 7 different roles. (See opposite page.)

During our contextual inquiries, we also spent varying amounts of time with other individuals who were not formally involved but shared work environments with our participants. These individuals' comments and activities were also incorporated into our research notes and accordingly attributed. Identities of all individuals in our research are confidential and referred to by pseudonym.

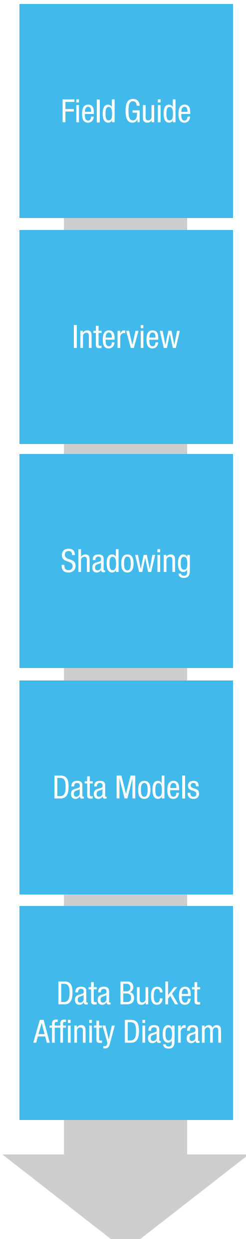
Considering the deep qualitative nature of contextual inquiry, the sample size was generous. (Best practice indicates three participants will suffice.) Given the breadth and intertwining of interactions in the hospital environment, as well as substantial differences between hospitals and departments, it was important to gather information from a larger than usual number of participants. This ensured that our data could be mined for common perceptions and trends as well as a greater number of breakdowns and workarounds for consideration.



University of Washington Medical Center (UWMC)
Abington Memorial Hospital (Abington)
Virginia Hospital Center
St. Luke's Bethlehem (Bethlehem)
St. Luke's Anderson (Anderson)


11 diagnostic radiologists
3 interventional radiologists
6 technologists
2 referring physicians
2 specialists
1 information technology representative
2 physician support services employees

DISCOVERY



GE Healthcare presented opportunities to immerse ourselves for long periods in different types of radiology settings: teaching and community hospitals, crowded and single-radiologist reading rooms, and the workspaces of several roles involved with our problem area. Daylong immersion in a single hospital enabled us to notice patterns that would have gone undetected and sensitive issues that would not likely be self-reported in surveys or standalone interviews. Studying different settings revealed common sources of interruption as well as notable divergences, and highlighted workarounds that, while exclusively employed in some areas, might be equally effective in others.

To aid in accomplishing our research objectives, we drafted a Field Guide (see Appendix) containing instructions and listing necessary resources to conduct our field research. In the field, we used the guide's Interview Protocol as a starting-point and gauge for our interviews.

Most of our four-person team's hospital visits were conducted in pairs. We found this to be particularly effective for several reasons:

First, because HIPAA (Health Insurance Portability and Accountability Act, which protects patient data) prevented us from recording audio or video—except in patient-data-free settings—dividing handwritten transcription duties between two researchers increased the authenticity and variety of recorded data.

Second, we found that teams of more than two researchers become increasingly distracting and possibly intimidating in a reading room.

Third, breaking into pairs enabled us to conduct research at two sites simultaneously.

PREPARATION & PILOT VISIT

Radiologists examine images together in the reading room.

Prior to our research arranged by GE Healthcare, we conducted informal interviews with two subject matter experts: a radiology resident at the University of Pittsburgh Medical Center (a teaching hospital) and a medical student in the Perelman School of Medicine at the University of Pennsylvania.

These interviews provided important opportunities to ask questions about what to expect in the radiology setting. Members of our team who were initially less familiar with this setting and problem area were thereby better able to prepare for our formal research forays. These interviews also helped to guide our research into competitive products and relevant literature.

We also spent four hours conducting an informal pilot visit at the University of Pittsburgh Medical Center. This visit increased our familiarity with the radiology setting and helped us to develop approximate standards by which to measure our formal research findings.

INTERVIEWS

We interviewed radiologists to understand their workflows and both verbal and tool-based communications. Our interviews aimed to collect responses to questions about specific job functions, the ebb and flow of daily activity, sources of inbound and outbound communication, communication tools and systems used, mobility and its relationship to availability and productivity, bottlenecks encountered, and the cycle of concentration-interruption-recovery.

Besides interviewing radiologists, we interviewed collaborators to understand how they choose to communicate, what information they exchange, and the level of urgency they associate with it.

Our participants in general were passionate about their work and anxious to share in the hope of improving the overall state of radiology. However, few participants were able to commit to structured interview sessions following our research plan's Interview Protocol. The irony of our study is that radiologists and technologists found it difficult to accommodate the interruption of an interview within their high-pressure, efficiency-driven work environment.

As a result, our interviews were conducted in fragments interwoven with longer periods of shadowing. Sometimes, we ventured to resume inquiry with a participant in what appeared to be a free moment; most often, we would wait for a participant to return to the interview at his own pace. We used our interview protocol as a guide and allowed participants to steer toward topics that they found relevant.

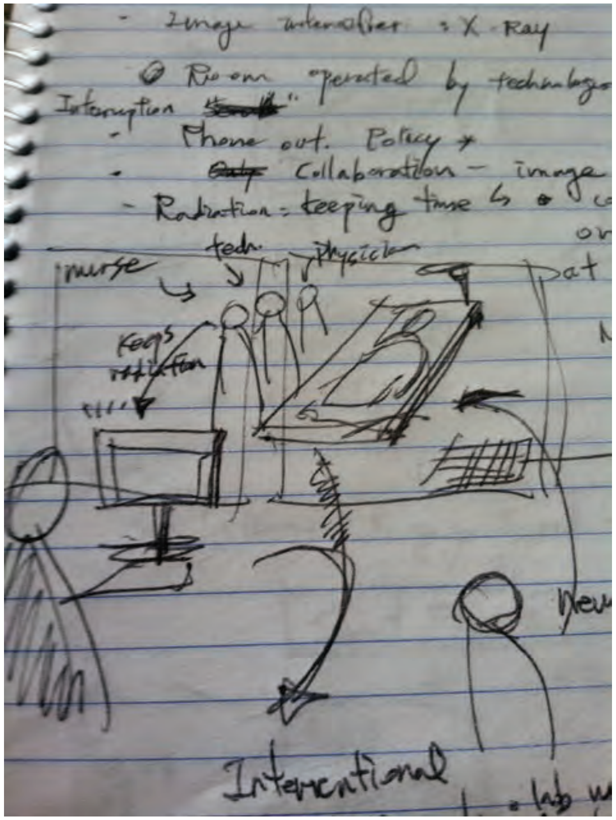
Radiologist interview protocol

- What is your primary job function?
- Can you walk us through a typical day for you? What times are busiest?
- Who do you usually interact with? Can you describe the nature of each interaction?
- What tools do you use to communicate with people and how often do you use each?
- When you're moving around, how does someone get ahold of you?
- Can you give me a brief tour of the systems you use?
- What systems are bottlenecks for you?
- If you had a magic wand that could create the perfect communication system for your work, what would that system look like?
- How often do you get interrupted? How fast are you able to recover?
- When are you the most productive, and how do you get there?

Collaborator interview protocol

- What is your job function?
- Can you walk us through your interactions with radiologists and describe both the information you want/provide and the level of urgency you associate with it?
- How do you locate radiologists?
- Do you use any software systems to access imaging data or relevant communication?
- Can you walk us through how you would do that (especially using any software systems)?

SHADOWING



In this sketch, the interventional radiologist relies on a team of techs and nurses to supply and record patient data throughout a surgical procedure

Using a method known as shadowing, we extensively observed participants and others in their work settings to discover the effect of context on workflow, collaboration and communication, and vice versa. Prior to shadowing, we instructed participants to continue working as if we were not present.

In shadowing, we documented activities, environments, interactions, artifacts, and culture. We kept our eyes open for screen real estate and tool use, workstation organization, layout, task flow, and prioritization. We kept our ears were open for discussion, jargon, mood and tone. We paid special attention to gadgets and workarounds. Despite our HIPAA-imposed recording restrictions, we time-stamped, measured, and depicted environments and artifacts. When a participant mobilized, we followed along.

The unstructured nature of our interviews sometimes caused participants to break the shadowing charade, pointing out aspects of their work they deemed important or, more often, frustrating. These real-time workflow walkthroughs—a comment here, an exclamation there—provided clarity far beyond what we had requested in our interview protocol.

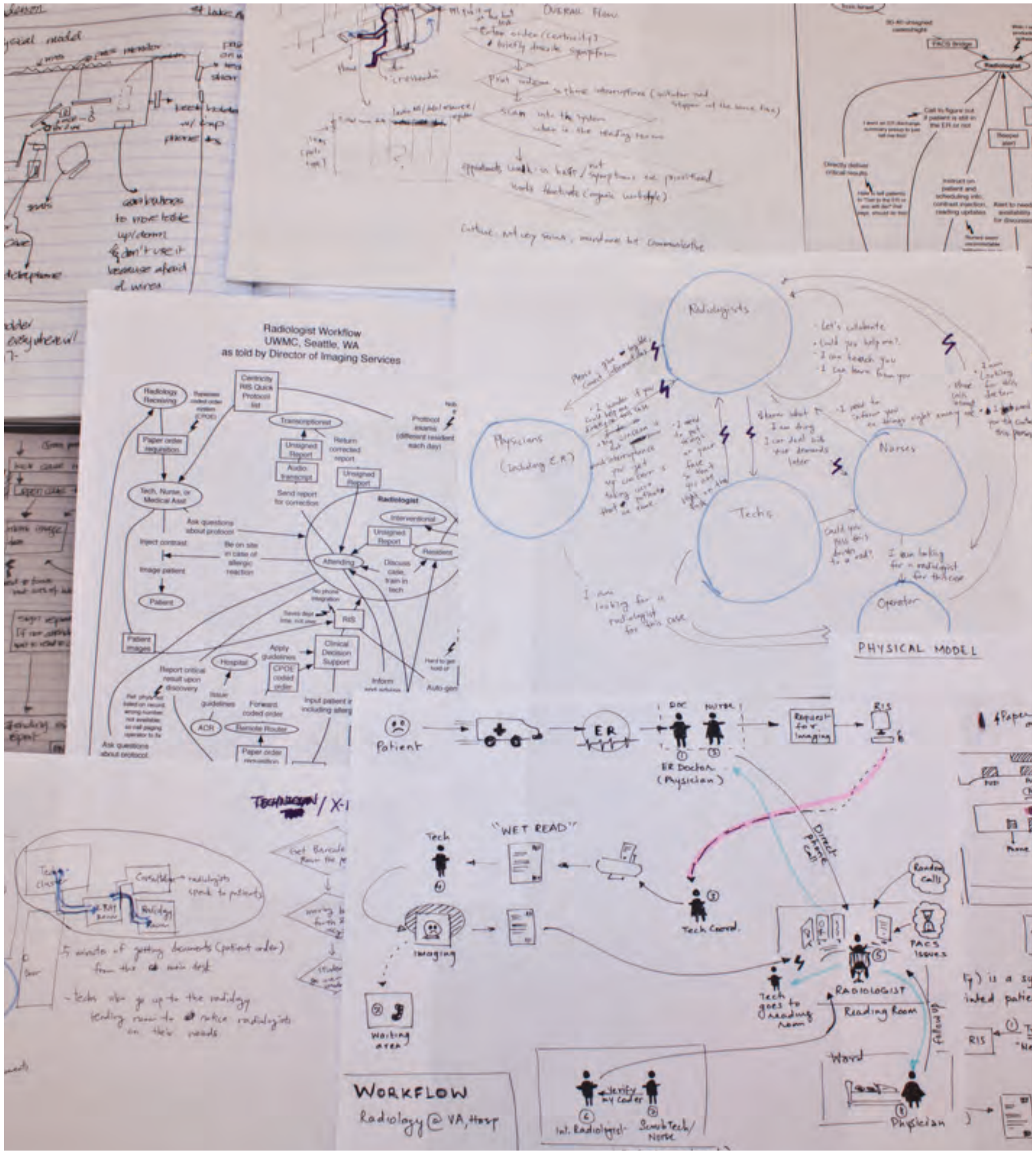
SYNTHESIS

DATA MODELS

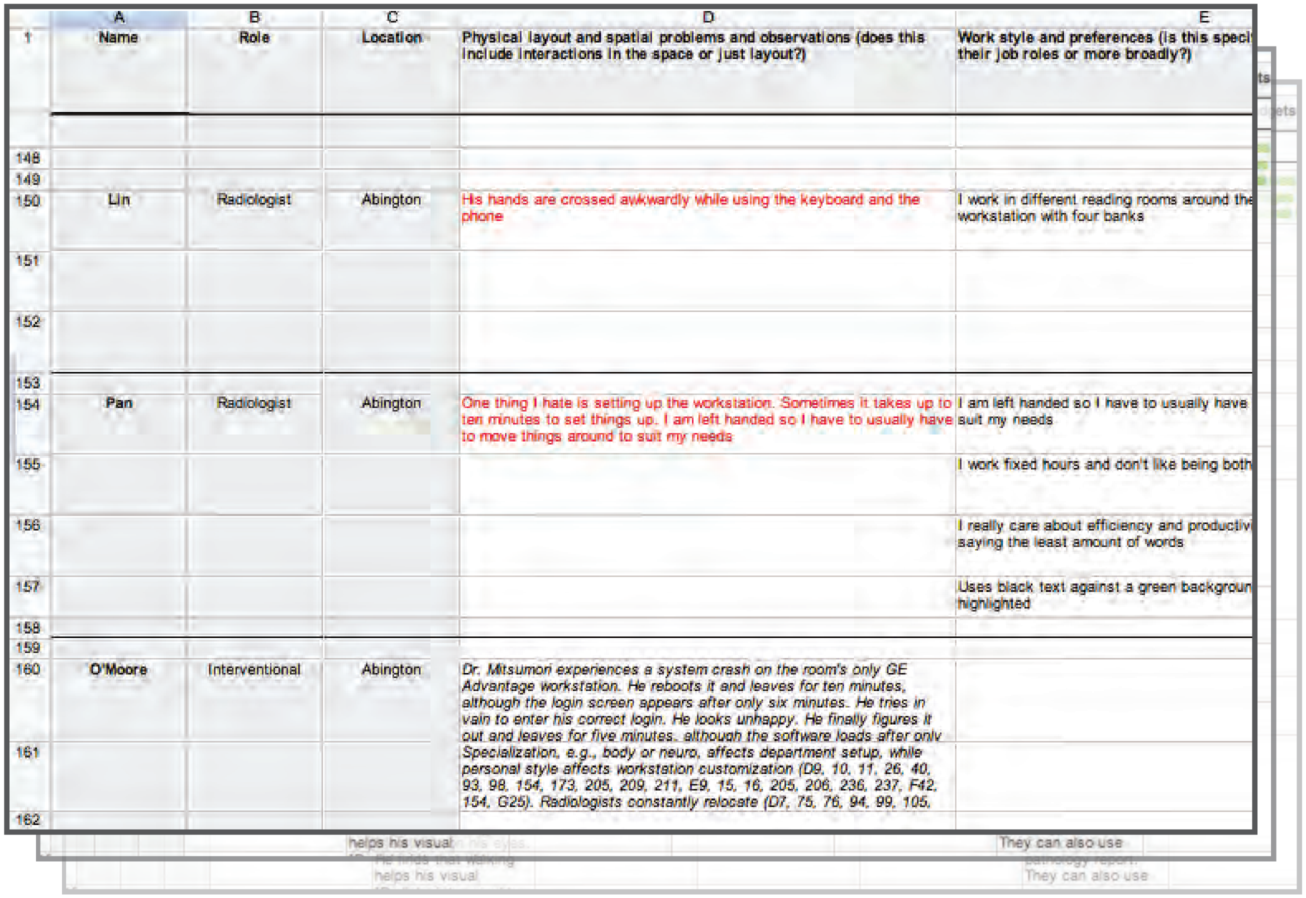
After we returned from each hospital visit, we transformed our handwritten notes and observations of workflows, sequences and settings into contextual models—maps and diagrams of the underlying structure of collected data.

We chose three types of models to embody our data: communication flow, sequence, and physical. These models help to clarify the major opportunities and breakdowns in radiologist collaboration and communication.

For all models, please see the Appendix.



Consolidating our models of observed field data helped to reveal common patterns of communication and collaboration



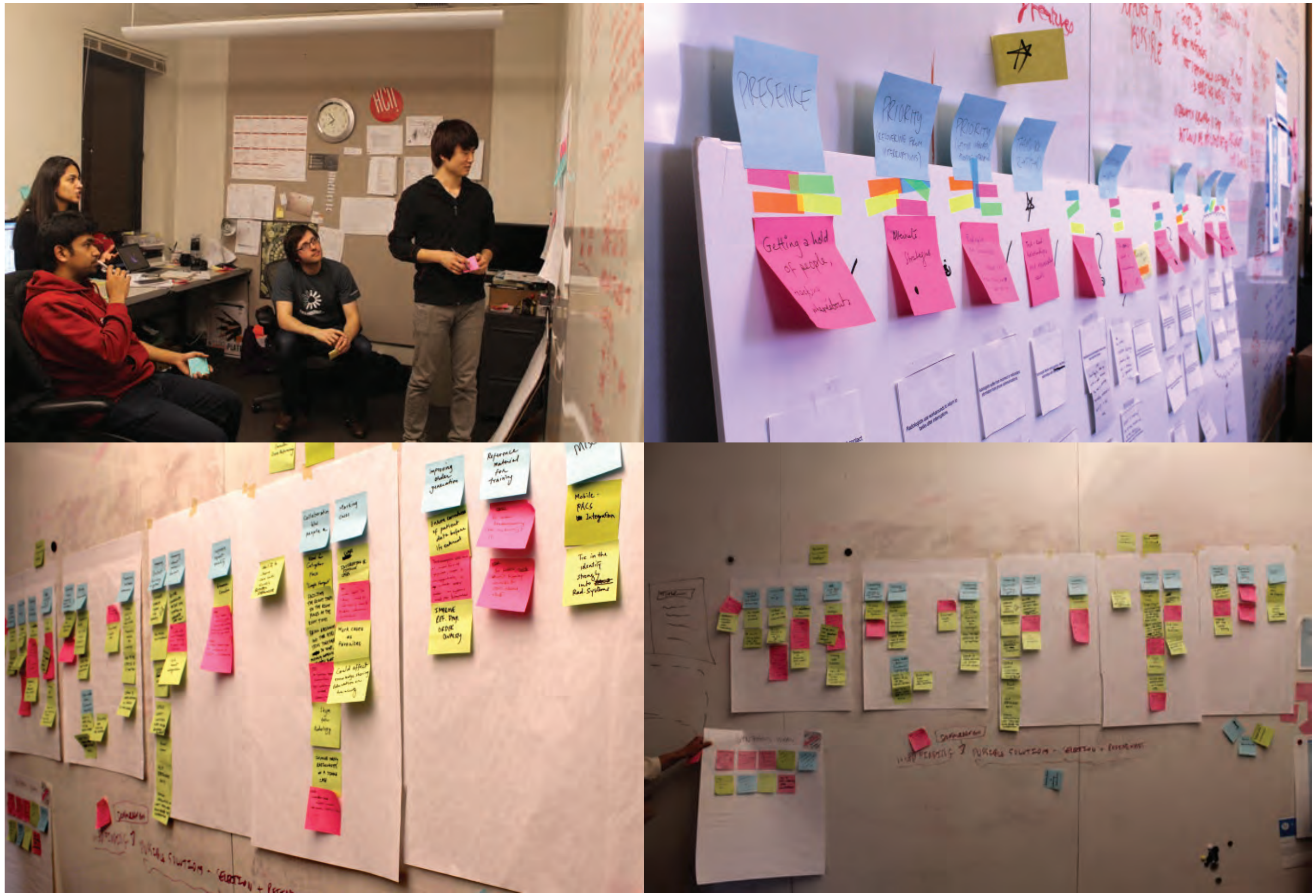
	A	B	C	D	E
1	Name	Role	Location	Physical layout and spatial problems and observations (does this include interactions in the space or just layout?)	Work style and preferences (is this speci their job roles or more broadly?)
148					
149					
150	Lin	Radiologist	Abington	His hands are crossed awkwardly while using the keyboard and the phone	I work in different reading rooms around the workstation with four banks
151					
152					
153					
154	Pan	Radiologist	Abington	One thing I hate is setting up the workstation. Sometimes it takes up to ten minutes to set things up. I am left handed so I have to usually have to move things around to suit my needs	I am left handed so I have to usually have suit my needs
155					I work fixed hours and don't like being both
156					I really care about efficiency and productiv saying the least amount of words
157					Uses black text against a green backgroun highlighted
158					
159					
160	O'Moore	Interventional	Abington	Dr. Mitsumori experiences a system crash on the room's only GE Advantage workstation. He reboots it and leaves for ten minutes, although the login screen appears after only six minutes. He tries in vain to enter his correct login. He looks unhappy. He finally figures it out and leaves for five minutes. although the software loads after only	
161				Specialization, e.g., body or neuro, affects department setup, while personal style affects workstation customization (D9, 10, 11, 26, 40, 93, 98, 154, 173, 205, 209, 211, E9, 15, 16, 205, 206, 236, 237, F42, 154, G25). Radiologists constantly relocate (D7, 75, 76, 94, 99, 105,	
162					

“Data bucket” spreadsheets reveal areas of interest and concern among participants

TRANSCRIPTION & SYNTHESIS

We transcribed our handwritten and audio notes (see Appendix) and used the transcripts to populate a “data bucket” spreadsheet. We grouped similar quotations and observations into columns, allowing themes to emerge organically.

SYNTHESIS



We used affinity diagrams to further clarify the themes revealed by our data buckets

AFFINITY DIAGRAMMING

Affinity diagrams are a method of collaboratively discovering and defining deeper themes in qualitative data. We selected themes with the most support and clustered them by shared affinities. Next, we interrogated each affinity cluster, applying five metrics:

1. Impact on Radiologists' workflow and patient care
2. Ease of achievability by GE Healthcare
3. Likelihood of competition—is it a blue ocean?
4. Consistency across all hospitals
5. Measurability by some set of metrics

We observed that the most fruitful affinity clusters fell underneath top-level categories:

1. Teamwork
2. Presence
3. Priority
4. Reliability

PERSONAS

Overview:

A persona is an abstracted representation of someone in a specific role. Drawing on our field observations, we created three personas to represent the key stakeholders in our research: the radiologist, the technologist, and the referring physician. These personas will help us to design solutions that fit the needs and desires of our target users.

RADIOLOGIST

"Things are constantly grabbing your attention."

Age: 40 years old
Context: Moves daily between reading room workstations
Alternate contexts: Operating room, imaging suite

Goals:

- Be as efficient as possible
- Provide good patient care
- Engage in timely communications
- Complete cases—with help, when necessary
- Stay current on technology and procedures
- Earn the respect of other radiologists and stakeholders

Frustrations:

- Bureaucracy
- Inability to locate needed stakeholders
- Redundancies and task loops (e.g., finding new cases or playing phone tag)
- Interruptions by mundane tasks
- Lack of sufficient insight into patient condition and history
- Lack of integration between systems and services

The radiologist protocols and reads patient examinations, sometimes requesting second opinions from other radiologists. He then dictates his findings in reports, attempts to inform referring physicians of any critical findings, and signs off on the reports. He communicates with other radiology stakeholders mostly in person and by phone. Occasionally, he teaches residents, helps them to read their own patient examinations, and signs off on their reports. If an interventional radiologist, he also performs interventional procedures approximately 30% of the time.

Radiologists are early adopters of new technology. We observed radiologists using and storing case data on personal devices such as smartphones, feature phones, tablets such as the iPad, and USB flash drives. These were in addition to their work in devices such as pagers, laptops, and cordless companion phones.

TECHNOLOGIST

"Not putting patients in danger is the most important thing."

Age: 27 years old
Context: Imaging suite, alternately chaotic and empty
Reports to lead technologist

Goals:

- Keep patients safe and provide quality care
- Develop specialization and perform interesting work

Frustrations:

- Lack of integration between systems, e.g. HIS, RIS, Excel, whiteboards
- Late or missing protocols

The technologist validates patient paperwork and prepares patients for imaging. She operates patient-scanning equipment based on protocols that sometimes require careful interpretation or double-checking with the radiologist. During scanning, she manages administration of radiation and contrast. She post-processes images per the radiologist's instructions. She also helps and covers for other technologists as needed.

REFERRING PHYSICIAN

"I don't care about interrupting anyone. People's lives are at stake."

Age: 45 years old
Context: In hospital or private practice, usually mobile

Goals:

- Provide best quality of care without regard for interrupting other stakeholders

Frustrations:

- Inability to locate radiologists
- Anxiety waiting for critical results, e.g., looking back at RIS

The referring physician determines the need for patient scans and orders these from the radiology department. After patient scans, the referring physician reviews the radiologist's reports and informs patients of critical results. He diagnoses patients and creates treatment plans based on his observations and the radiologist's reports. He may also collaborate with radiologists to improve patient care on a case-by-case basis.

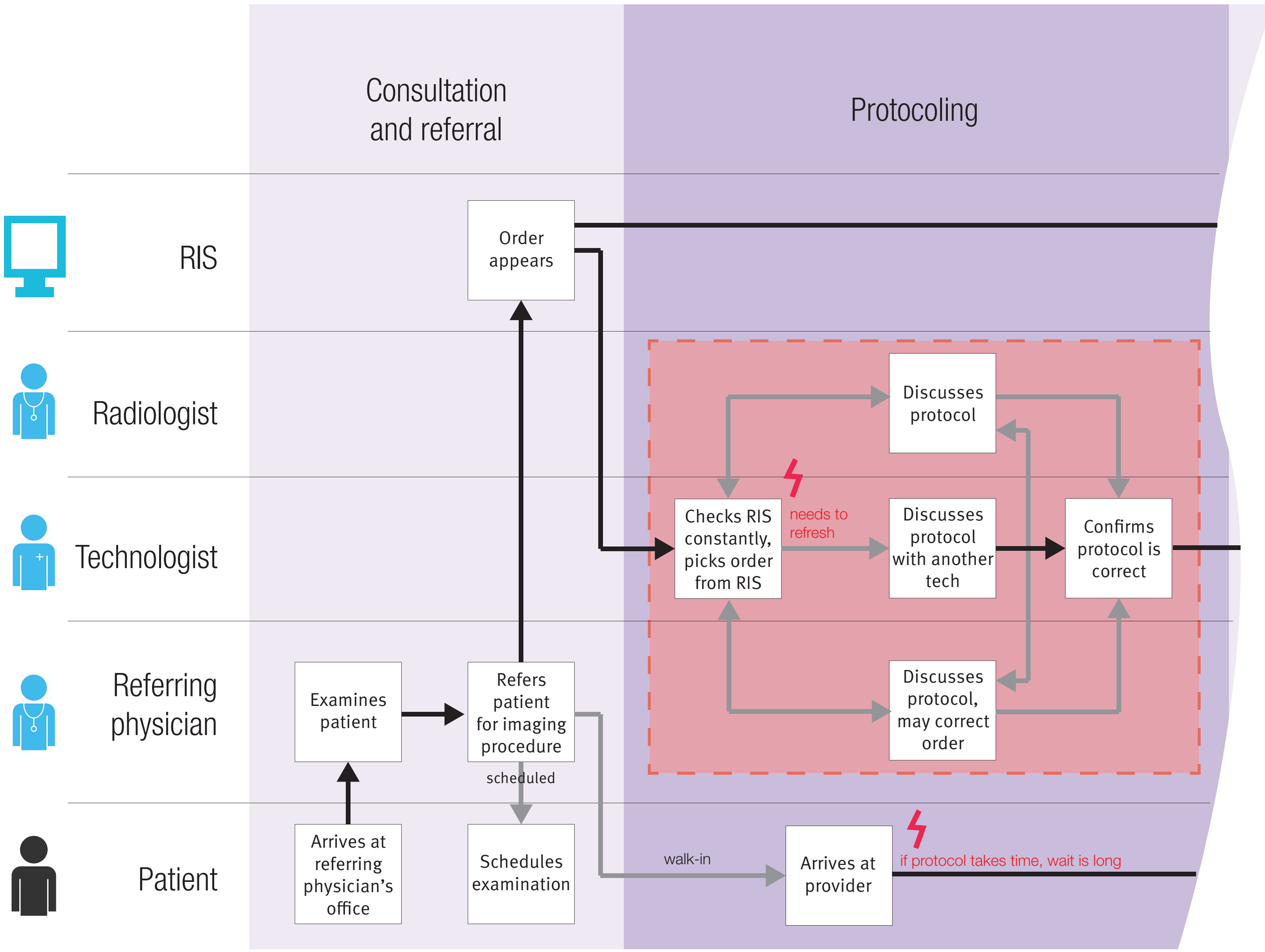
KEY WORKFLOWS

Overview:

We consolidated our models into a service flow diagram to highlight common collaborations and interruptions between stakeholders over the life of a single case.

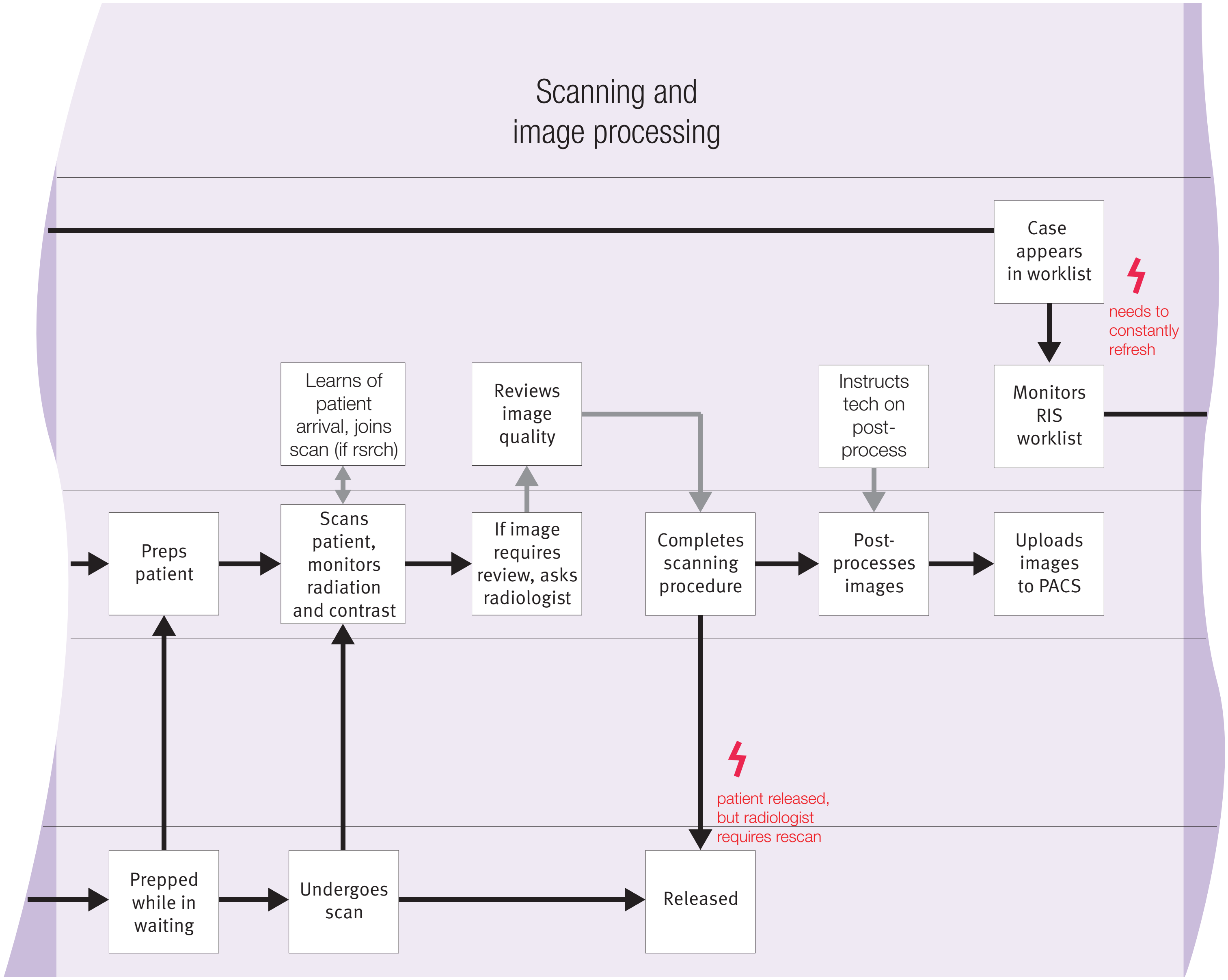
Radiologists were frequently interrupted during protocoling and image review. They also had difficulties in three main areas of communication breakdowns. Likewise, these are three areas of great opportunity for improvement by design:

- Reporting critical results to referring physicians
- Interpreting order requisitions
- Creating report content



Consultation and referral
Protocoling
RIS
Radiologist
Technologist
Referring physician
Patient
Order appears
Discusses protocol
Checks RIS constantly, picks order from RIS
needs to refresh
Discusses protocol with another tech
Confirms protocol is correct
Discusses protocol, may correct order
Examines patient
Refers patient for imaging procedure
scheduled
Arrives at referring physician's office
Schedules examination
walk-in
Arrives at provider
if protocol takes time, wait is long

KEY WORKFLOWS



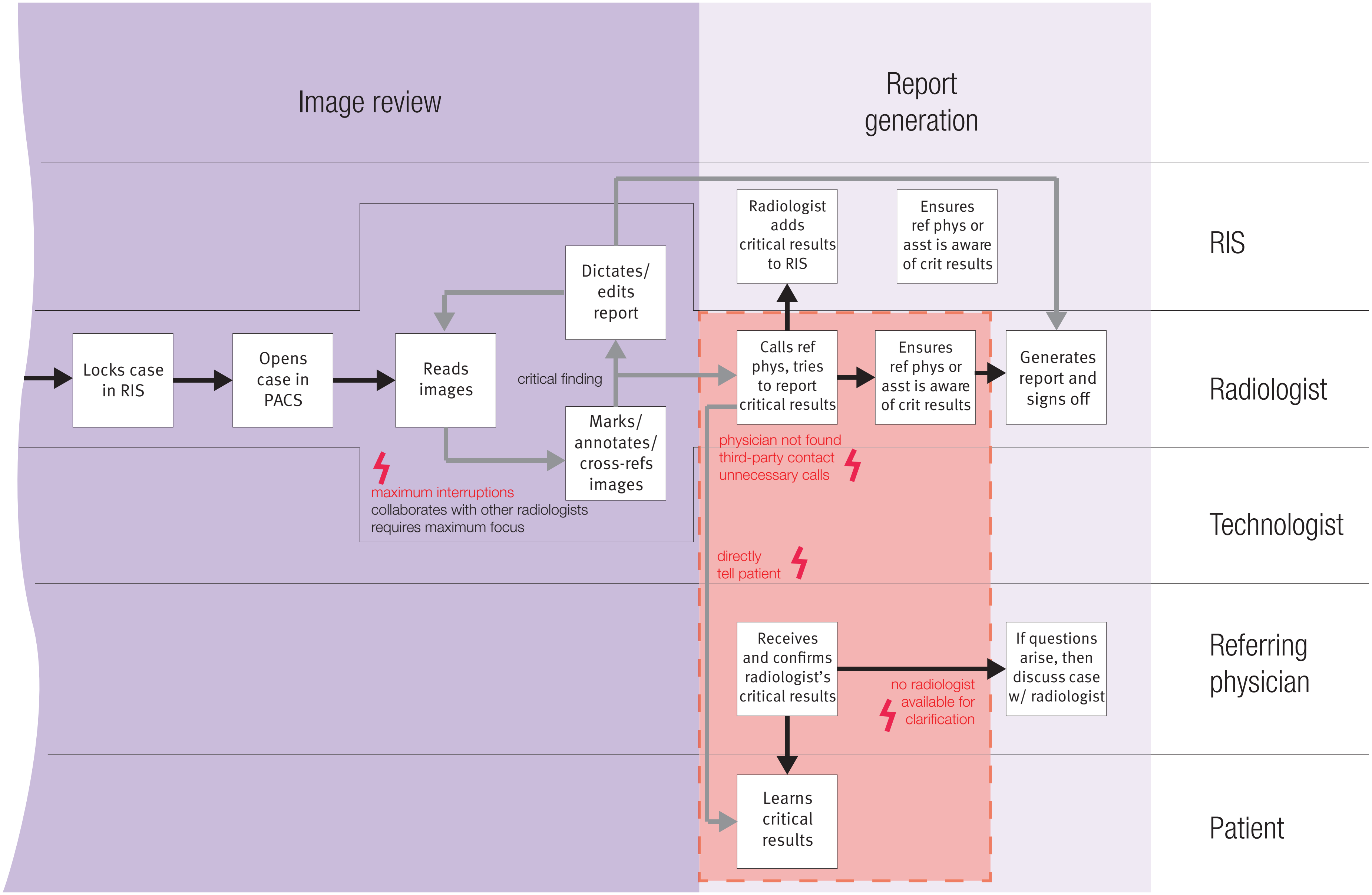


Image review
Report generation
RIS
Radiologist
Technologist
Referring physician
Patient
Locks case in RIS
Opens case in PACS
Reads images
Dictates/ edits report
critical finding
Marks/ annotates/ cross-refs images
maximum interruptions
collaborates with other radiologists
requires maximum focus
Radiologist adds critical results to RIS
Ensures ref phys or asst is aware of crit results
Calls ref phys, tries to report critical results
Ensures ref phys or asst is aware of crit results
Generates report and signs off
physician not found
third-party contact
unnecessary calls
directly tell patient
Receives and confirms radiologist's critical results
If questions arise, then discuss case w/ radiologist
no radiologist available for clarification
Learns critical results

FINDINGS

OVERVIEW

"If you get the best equipment but if you can't communicate, then you will fail."

-Janis, Coordinating Technologist

1. **Teamwork** is undervalued: While radiologists are given tools and encouragement to be productive as individuals, they rely heavily on teamwork to maximize productivity and to remove stumbling blocks. A large part of the radiologist's work is communicating with various people across departments. Design systems that support and encourage teamwork at collaborators' mutual convenience.

2. Systems fail to account for **mobility and presence**: Most existing designs fail to account for the mobility of physicians. There is no good way to locate people when you need them. Create solutions that facilitate effective communication in consideration of mobility.

3. Interruptions create desire for **prioritization**: Differentiating between useful and unimportant communication is the hard part. Radiologists seek to prioritize certain types of interruptions and deal with them at their own pace. Provide mechanisms to help radiologists rank incoming communications.

4. Low system **reliability** wastes time and causes frustration: Although the reliability of systems and patient data greatly impacts productivity and quality of care, radiologists report that providers are not paying to upgrade entire systems. Shift focus from full-scale system overhauls to improving existing designs, reducing inconsistencies and improving performance.

These findings shaped our visions for possible prototypes. Guidelines and recommendations are suggested to GE Healthcare based on field observations by Shoal.

For more on our visions, please turn to page 64.

1. TEAMWORK IS UNDERVALUED

While radiologists are given tools and encouragement to be productive as individuals, they rely heavily on teamwork to maximize productivity and to remove stumbling blocks. Today's systems do not support and encourage teamwork.

DESIGN GUIDELINE 1

Design systems that support and encourage teamwork at collaborators' mutual convenience.

We found strong relationships between radiologists and other radiologists, technologists, and referring physicians. Radiologists worked closely with technologists to protocol cases and less frequently to perform scans at teaching hospitals. Radiologists consulted other radiologists for training and advice. Referring physicians provided radiologists with patient insights and context for diagnostic images. Teamwork was especially prevalent at teaching hospitals, but still frequent at other providers.

TEAMWORK

"If you want to do high-level radiology, the best radiology, you need to get everyone in the same room."

-Dr. Bob, Attending Radiologist

RADIOLOGISTS THRIVE ON QUICK, FOCUSED CONFERENCES.

We saw radiologists improve diagnosis quality by collaborating with and educating other radiologists and referring physicians. Attending radiologist Dr. Bob said, "Scheduled conferences are extremely effective. You can discuss interpretations with other radiologists. For example [points to a PACS image], 'There's white stuff there. What is the white stuff?' If you want to do high-level radiology, the best radiology, you need to get everyone in the same room."

One notable form of collaboration we observed was the conference. For example, referring physicians and specialists visited radiologists to discuss current cases at scheduled tumor board reviews. While the radiologist spent a mere fifteen to thirty seconds responding to referring physicians' descriptions of each case, he and the referring physicians exited the meeting smiling and commenting that the conference resulted in better patient diagnoses.

At teaching hospitals, we frequently saw attending radiologists meet with residents to review their cases. Also, one UWMC attending radiologist gave a quick PACS tutorial to several residents over a lunch break.

Radiologist Dr. Adama predicted, "My theory is that radiologists are going to cloud compute and will be tweeting back and forth. Why should I be the only one looking at a complicated case? I have a limited IQ. If you could combine that with others' intelligence, you could do a better job."

However, in some locations, radiologists reported a lack of interest in conferences because of scarce funding and an intense focus on report turnaround time.

Recommendation

Design systems to allow for quick, scheduled meetings resulting in better diagnosis and training.

"Call Maria, call transcription. She can fix it." -Attending Radiologist

COLLABORATION SOLVES UNEXPECTED PROBLEMS.

At all five locations, we saw radiologists rely on each other for advice and expertise. Many radiologists, especially at UWMC, St. Luke's Bethlehem, and St. Luke's Easton, asserted that this reliance resulted in more accurate patient diagnosis. We often watched radiologists ask for second opinions on challenging images and unprecedented situations.

For example, at UWMC, we overheard an exasperated resident tell an attending radiologist, "The overnight resident rolled everything into one report." The attending radiologist responded, "Call Maria, call transcription. She can fix it or figure out how to get it done."

Recommendation

Design systems to help radiologists to get and give peer advice.

TEAMWORK

"Every fifteen to twenty minutes, someone needs an opinion or answer for something." *-Dr. Adama, Radiologist*

TECHNOLOGISTS BENEFIT FROM COLLABORATION WITH RADIOLOGISTS.

Technologists often collaborated with radiologists about cases and protocols in person, by phone or by pager. Even experienced technologists were observed asking radiologists for help translating referring physicians' order requisitions into optimal imaging protocols. In at least five instances, conversation revolved around the RIS.

If a radiologist was unavailable to help translate or verify a questionable protocol, the technologist and patient were both forced to delay the scanning procedure.

One radiologist, Dr. Adama, commented, "We have a great relationship with the techs. I encourage them to come whenever they have a question. It's kind of like every fifteen to twenty minutes when someone needs an opinion or answer for something."

Recommendation

Systems should allow technologists to request timely feedback on protocols without multiple communication tools, minimizing patient wait time.

"Remote radiology? It would be easier for radiologists to actually be here [in the mobile control room]. They can be hands-on with the scanner. They couldn't do that screen-to-screen." *-Earl, Technologist*

TECHNOLOGISTS AND RADIOLOGISTS MAY COLLABORATE IN THE CONTROL ROOM TO ESTABLISH RESEARCH PROTOCOLS.

At teaching hospital UWMC, we observed a research unit that uniquely combined mobile control room, experimental scanning equipment and reading room. Here, the radiologist collaborated with the technologist to establish and test protocol on patients. Usually, the radiologist processed the previous scan while the technologist tested the protocol. But sometimes, the radiologist himself operated the scanning equipment.

Technologist Earl asserted, "Remote radiology? It would be easier for radiologists to actually be here [in the mobile control room]. They can be hands-on with the scanner. They couldn't do that screen-to-screen."

Recommendation

Make systems flexible enough to support heavy interaction between technologist and radiologist for complicated or untested protocols.

TEAMWORK

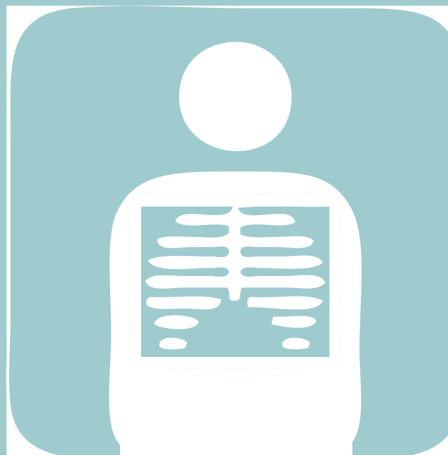
RADIOLOGISTS AT SOME RESEARCH FACILITIES REMOTELY CONTROL SCANNING EQUIPMENT.

Teaching hospital UWMC mounted LCD screens in the Body Department reading room to display live scanning feeds. Body radiologists speaking by phone with technologists in the control room either approved or requested re-scans of on-screen images. Radiology fellow Horace described experiencing a similar system at New York University that allows radiologists to remotely manipulate scanning equipment from the reading room.

We observed a surgical procedure during which an interventional radiologist prompted a technologist to take a live feed for an image.

Recommendation

Consider integrating live scanning feeds and approval mechanisms into PACS for teaching hospitals and other research institutions.



2. SYSTEMS FAIL TO ACCOUNT FOR PRESENCE AND MOBILITY

Most existing designs fail to account for the mobility of physicians.

DESIGN GUIDELINE 2

Create solutions that facilitate effective communication in consideration of mobility.

Radiologists constantly relocate. Five radiologists discussed switching daily between workstations and reading rooms. We saw radiologists at three locations work different shifts on different days. In one hospital, we saw radiologists rotating between different sites during their week. Four radiologists spent part of a shift in the reading room and the rest of it in the control room working with a technologist.

UWMC Physician Support Services employee Laura sympathized, *"They [radiologists] are very busy. It's hard for them. The [work] list is so long, and they keep getting called away to meetings, clinicians, conferences, all over."*

PRESENCE & MOBILITY

"They keep getting called away to meetings, clinicians, conferences, all over."

–Laura, Physician Support Services Employee

CURRENT SYSTEMS LOSE TRACK OF MOBILE PHYSICIANS.

Radiologists need to be available at all times to communicate with collaborators on a timely basis about issues affecting patients' lives. However, because radiologists are so mobile, they are difficult to reach by phone. Many hospitals have paging systems to alert mobile radiologists, and we observed radiologists carrying pagers at two locations. Still, even paging systems sometimes failed to reach radiologists.

Radiologists at different locations use different workarounds to remain available. One provider did not have cellphone towers set up in its area, so it gave radiologists cordless companion phones. Another provider gave a lead technologist a cellphone restricted to work-related data.

Radiologist Dr. Adama said, "If they know my direct number, they'll call it. We have a central phone number.... There, they have people who answer the phone. So if someone wants to call me, they can call them. They'll know where I am. They'll transfer the call to my phone."

At UWMC, physician support services employees screened missed calls and alerted radiologists at the earliest opportunities. In fact, physician support services employee Laura added, "[Even] if radiologists are busy in other reading rooms, their calls [also] get transferred here."

Recommendation

Implement a system to forward urgent messages to radiologists when they are away from their workstations.

"We try to get the secretaries to look up [referring physicians] for us. I need to contact them multiple times a day." -*Horace, Radiologist Fellow*

CALLING REFERRING PHYSICIANS IS A GAME OF PHONE TAG.

Radiologists often struggled to alert physicians to discoveries of critical results—potentially life-threatening abnormalities observed in patient images. Radiologists must record the date and time they communicate critical results before signing off on such a report. Radiologists need quick access to referring physicians' contact information, but at least five radiologists expressed frustration with getting hold of referring physicians.

Sometimes, radiologists could not locate contact information. Other times, contact information was located in a separate, external system. One solution we observed was to offload the problem onto dedicated administrative personnel: The UWMC physician support services employees were particularly helpful in connecting radiologists with referring physicians.

Recommendation

Design a system to more quickly connect and facilitate communication between the radiologist and referring physician.

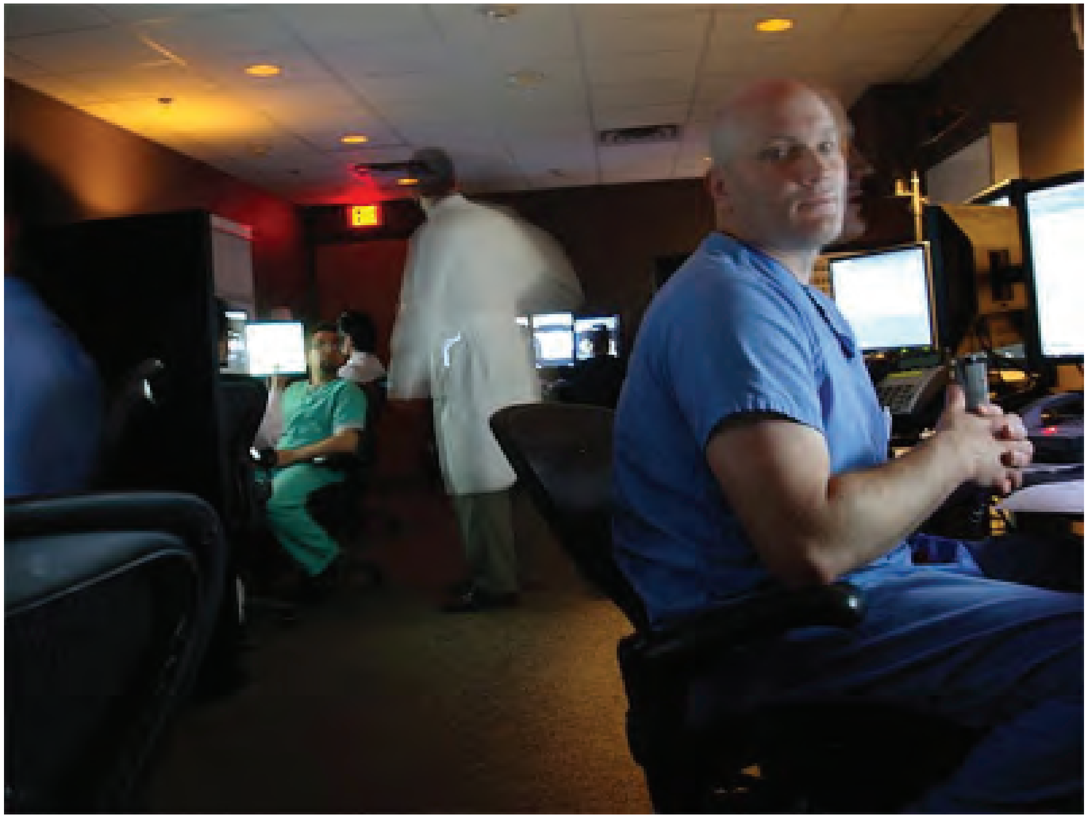
PRESENCE & MOBILITY

PATIENTS ARE AFFECTED BY COMMUNICATION BREAKDOWNS BETWEEN RADIOLOGISTS AND REFERRING PHYSICIANS.

Several radiologists asserted that communication between the radiologist and referring physician is key to good patient diagnosis. We watched communication breakdowns force patients to wait anxiously for a scan and sometimes to repeat the same scan multiple times, resulting in potentially unsafe radiation exposure levels. In some cases, important information was not passed to the referring physician. In other cases, the wrong physician was listed and contacted. Such situations are hard to track until the patient becomes aware and alerts the radiologist.

Recommendation

Design systems to increase the likelihood that patient requirements are satisfied by or before scheduled appointments.



Radiologists are constantly in motion.

3. INTERRUPTIONS CREATE DESIRE FOR PRIORITIZATION

Differentiating between useful and unimportant communication is the hard part. Radiologists seek to prioritize certain types of interruptions and deal with them at their own pace.

DESIGN GUIDELINE 3

Provide mechanisms to help radiologists rank incoming communications.

Participants at every provider we visited stressed the importance of prioritizing radiologists' communication to prevent it from overwhelming them. Radiologists fielded three to five-minute phone calls and visits many times daily, resulting in thirty minutes to two hours of daily interruptions. They discussed PACS and protocols with technologists, protocols as well as urgent cases with referring physicians, and patient data with nurses. Phone and visitation interruptions persisted even at UWMC, where physician support services staff screened calls.

Interventional radiologist Dr. Alberts said, *"It is impossible for incoming requests to be segregated into things that require emergent answers, things that could wait twenty minutes, and things that could wait twenty days. Nothing segregates them in the order of urgency."*

PRIORITY

"I need to get hold of a radiologist immediately and cannot wait for phones to ring. I need direct access."

-Dr. Ronson, Referring Physician

SOME INTERRUPTIONS ARE ESSENTIAL.

Referring physicians, who initially transmitted patient data to radiologists through the HIS and PACS, later called or visited radiologists about complex and urgent cases. Radiologists acknowledged the need to prioritize these urgent communications and sometimes initiated calls to technologists or other radiologists to improve their understanding of complex cases and to discuss critical results. Dr. Adama said, "It depends on the circumstances. If it's an emergency patient, I'm going to get through to someone eventually. If it was some case with cancer of the liver, I got through to someone the next day. And I made sure he got my report."

Referring emergency room physician Dr. Ronson said, "I need to get hold of a radiologist immediately and cannot wait for phones to ring. I need direct access."

Recommendation

Enable radiologists to effectively use asynchronous communication to prioritize urgent cases.

"Often, the patient just shows up and surprises us with incompatible patient info."

-Earl, Technologist

LACK OF COORDINATION BREEDS POOR COMMUNICATION.

Callers and visitors sometimes interrupted radiologists working on emergency cases with information already communicated via preceding patient reports and HIS/PACS notifications.

Sometimes, technologists received erroneous information from referring physicians or patients, prompting them to inquire with radiologists. Technologist Earl said, "Most of the time, the physicians and techs rely on protocols, where patients will not note things properly on exam paperwork—for example, previous surgical implants. Sometimes, we have to contact the doctor, look online, see if the code is MR [magnetic resonance] compatible. We try to get a screening form from each patient first. But often, the patient just shows up and surprises us with incompatible patient info. This is wasted time."

To correct errors quickly, radiologists often called referring physicians. Technologists and nurses called or visited radiologists unnecessarily whenever they missed errors or were unaware of radiologists' attempts to correct them. Dr. Tsai told us, "Approvers get no notifications when he [the radiologist] is done reviewing a study and reporting his findings."

Recommendation

Enable radiologists and collaborators to effectively use asynchronous communication to reduce redundant communications and simultaneously share information with all relevant stakeholders.

PRIORITY

“The patient has to wait on the table. Techs and patients start to freak out.”

–Earl, Technologist

DISPUTED PROTOCOLS CAUSE DELAYS AND INCREASE URGENCY.

While technologists could usually rely on existing protocols, they occasionally contacted radiologists after noticing something unusual that might seriously affect a case. Disputed protocols caused frustration for radiologists and anxiety among technologists and patients.

Technologist Earl said, “How do we fix protocols? So, first we look at the protocol. If it looks wrong, we go to the requisition. We just fix the requisition form if it’s minor. If it’s major, we contact the radiologist. Until the radiologist gets in touch to fix things in the protocol, the patient has to wait on the table. Techs and patients start to freak out a little.”

Recommendation

Design systems that encourage radiologists to prioritize communications that directly affect patient care.

"I wish there was more instant messaging for radiology."

-Dr. Tsai, Radiologist

RADIOLOGISTS STRONGLY DESIRE ASYNCHRONOUS COMMUNICATION WHEN MOBILE.

Unprompted, several radiologists expressed a desire for asynchronous communication tools when mobile. The following are several sample statements by radiologists we interviewed.

Interventional radiologist Dr. Alberts said, "Just make Skype for medicine. It follows you around on your phone and on your system. It connects you to all the doctors and presents you with the information you need."

Attending radiologist Dr. Bob suggested, "Radiology could make better use of iPhones."

Radiologist Dr. Tsai added, "I wish there was more instant messaging for radiology."

Interventional radiologist Dr. Sun suggested, "All informational phone calls can go through a notification system instead of a phone."

Recommendation

Integrate mobile and remote technology capable of transmitting supplementary images and information.

PRIORITY

"I write a note to myself to remember. I write when I have spoken with someone."

–Dr. Bob, Attending Radiologist

RADIOLOGISTS IMPROVISE REMINDERS AND CHECKLISTS TO RECOVER FROM INTERRUPTIONS.

When interrupted in the middle of dictation, all fourteen radiologists we studied recorded their actions or used some form of reminder to facilitate subsequent recovery. Four radiologists used reminder notes from a conversation, and one used OneNote productivity software to digitally record his actions. Radiologists sometimes used macros to bookmark points of interruption.

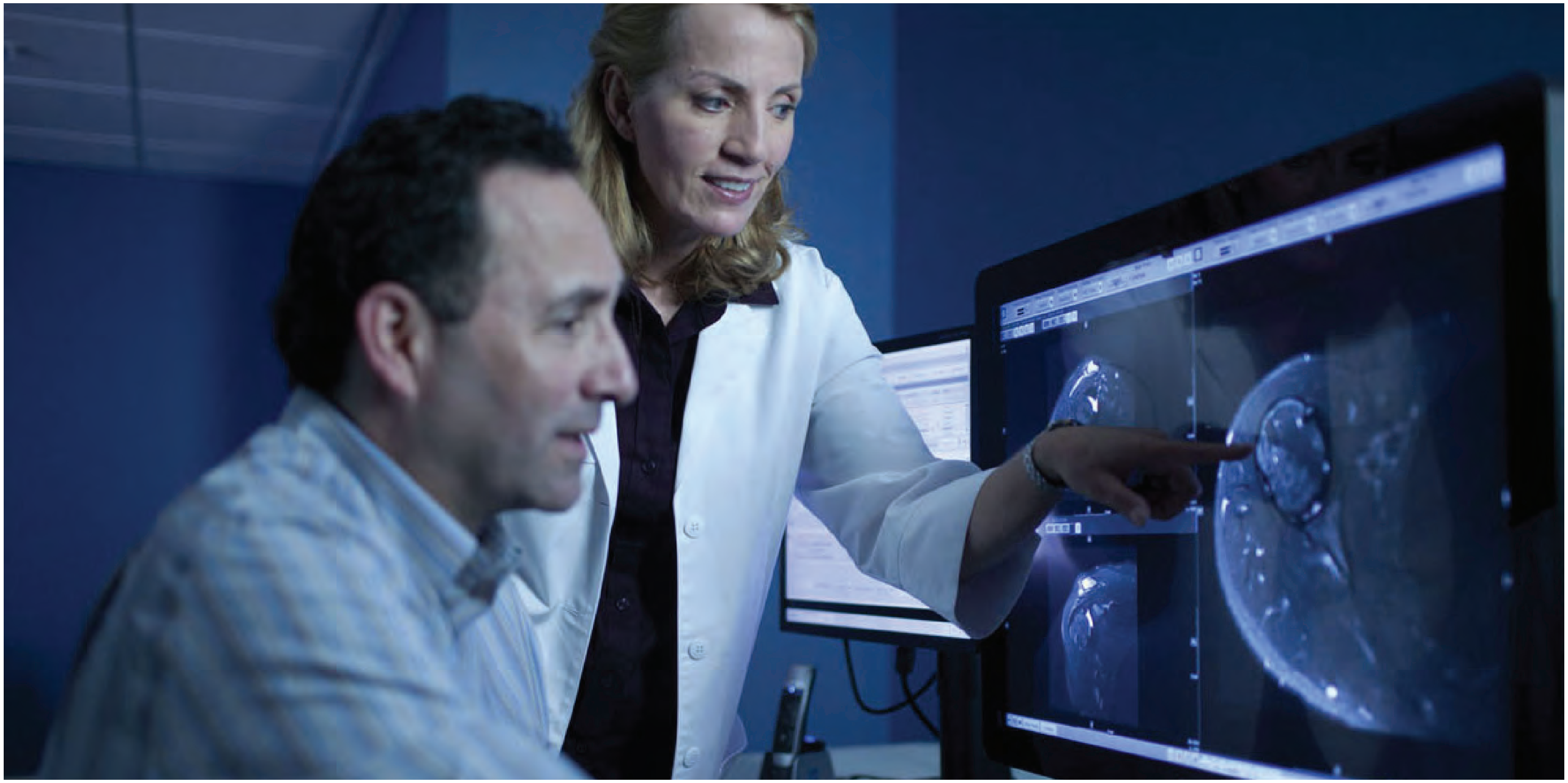
Attending radiologist Dr. Bob said, "I page people, but I write a note to myself to remember. I write when I havespoken with someone."

Some radiologists used PACS color labels to document whether the case had been discussed and whether related tasks had been assigned. Radiologists also improvised checklists, like email inboxes, to prioritize and to monitor daily tasks. For example, one radiologist told us that he used his email inbox like a task list.

Dr. Bob suggested, "Push a button in PACS and it calls the referring physician, that would be useful. I want to be able to do everything in real-time. Later, I tend to forget cases. There's no good way to queue cases. When are you going to catch up, anyway? You need to do it all on the fly."

Recommendation

Integrate reminders, favorites, shortcuts, indications of current case status, and/or other recovery tools directly into PACS and the RIS. Also, consider enabling communication radiologists to collaborate with referring physicians from within PACS or the RIS.



Prioritized coordination is essential for radiologists to avoid interruption

4. LOW SYSTEM RELIABILITY WASTES TIME AND CAUSES FRUSTRATION

Although the reliability of systems and patient data greatly impacts productivity and quality of care, radiologists report that providers are not paying to upgrade entire systems.

DESIGN GUIDELINE 4

Shift focus from full-scale system overhauls to improving existing designs, reducing inconsistencies and improving performance.

Unreliable systems affect radiologists' productivity and quality of care. Every radiologist we studied highlighted opportunities to improve PACS. Radiologists and technologists also encountered unreliable patient medical history in the EMR. We found opportunities to increase consistency within and between PACS, the RIS, and the HIS.

RELIABILITY

SYSTEMS DISCUSSED

PACS
The Picture Archiving and Communication System stores images generated by every examination or procedure conducted in the radiology department, and radiologists use PACS to view examinations, record findings and communicate critical results.

RIS
The Radiology Information System maintains the list of cases that need attention from a technologist or radiologist, and the RIS is populated by patient information when one signs up for an exam.

HIS
Radiologists primarily use the Hospital Information System to retrieve schedules or contact information for anyone with whom they wish to communicate. A provider creates an Electronic Medical Record (EMR) or digital patient record to monitor the patient on location.

"Why can't I just get the last ten studies that I've accessed in a separate menu or something for easy access?"

-Dr. Deng, Radiologist

RADIOLOGISTS LACK QUICK ACCESS TO RECENT CASES.

Three radiologists requested easier access to recently opened cases. Radiologists were interrupted multiple times a day about one case while working on another. After dealing with the interruption, they had to perform a lengthy process to reopen the interrupted case.

Radiologist Dr. Deng asked, "Why can't I just get the last ten studies that I've accessed in a separate menu or something for easy access?"

Recommendation

Enable radiologists to easily access recent PACS cases.

RELIABILITY

"I'm only as good as the information I provide."

–Dr. Cranston, Interventional Radiologist

LACK OF GRAMMAR CORRECTION LEADS TO SLOWER DICTATION.

Radiologists said they cared deeply about the quality of their reports because they were the sole records by which others, especially referring physicians, would judge their competence. Dr. Cranston emphasized, "We're doctors for doctors. For the most part, I'm only as good as the information I provide. That is how I judge myself." However, without sufficient grammar correction, dictation software made syntactical and grammatical errors that worried these radiologists about the quality of their reports.

To preserve report quality, many radiologists felt compelled to dictate and edit in chunks. Some radiologists said this dictation style disrupted the flow of their thoughts and slowed their dictation speed.

Recommendation

Integrate grammar and syntax correction with dictation software. Provide upgrades for existing software.

"I waste over 40 minutes of my day doing exactly this: selecting each and every image with my mouse while trying to cross-reference them."

–Dr. Tsai, Radiologist

REDUNDANT PACS FEATURES SLOW THINGS DOWN.

GE and Siemens PACS often required a long sequence of steps to be performed for a single function. For instance, cross-referencing images across studies required the user to select each image by clicking it. Radiologists use this function and others like it multiple times daily.

Without a shortcut to select all images, radiologist Dr. Tsai said, "I waste over 40 minutes of my day doing exactly this: selecting each and every image with my mouse while trying to cross-reference them."

Recommendation

Thoroughly review the sequence of PACS functions to eliminate redundancy and provide shortcuts for frequently used functions.

RELIABILITY

"A lot of scheduling happens on the fly."

–Holly, Technologist

WORK LISTS ARE NOT PRIORITIZED AND MUST BE CONSTANTLY MONITORED.

All radiologists said that they constantly monitor the RIS for new cases. Some were frustrated by this additional demand on their attention. Filtering by imaging modality, like MRI, CT scan, or x-ray, was insufficient. Also, five radiologists specifically selected cases related to their specializations, often leaving less interesting cases unexamined for a day or more.

We observed technologists, too, preferentially selecting particular cases. Technologist Holly explained, "[Our] technicians often swap cases or exchange them based on their personal preferences. A lot of scheduling happens on the fly."

Recommendation

Enable radiologists and technologists to prioritize and customize work lists without abandoning less appealing cases.

"There is no data integration. There is clinical integration, but that is useless for radiologists."

–Dr. Alberts, Interventional Radiologist

DISCONNECTED PATIENT DATA AND INACCURATE PATIENT HISTORY CAUSE INTERRUPTIONS.

During a patient's pre-exam, technologists were required to verify details about the patient's medical history. Patients were sometimes unable to recollect this information, nor could it be located in the EMR. In these cases, technologists interrupted radiologists to look up patients' past images and confirm certain facts before the exam.

In two contextual inquiries, radiologists needed pathology lab results for a patient whose images they were reviewing. According to interventional radiologist Dr. Alberts, these results were not integrated with PACS, the RIS, or related systems systems: "Labs are not available. There is no data integration. There is clinical integration, but that is useless for radiologists." We observed radiologists using a web browser to access these records from another system, and the procedure for this was time consuming.

One radiologist we shadowed noticed a discrepancy between a patient's information in the EMR and images in the PACS. The radiologist recognized the mismatch because the patient happened to be a seven year-old boy, but the images were for a much older person. He mentioned later that this had happened many times before and might someday have serious consequences for the patient and the provider.

Recommendation

Improve integration of EMR with PACS and the RIS. Consider providing radiologists with the ability to add findings directly into the EMR.

VISIONING DIRECTIONS

OVERVIEW

Based on our research, we identified areas of opportunity where a new product could have significant impact. To facilitate discussion around these opportunities, we present three scenarios addressing the following problems:

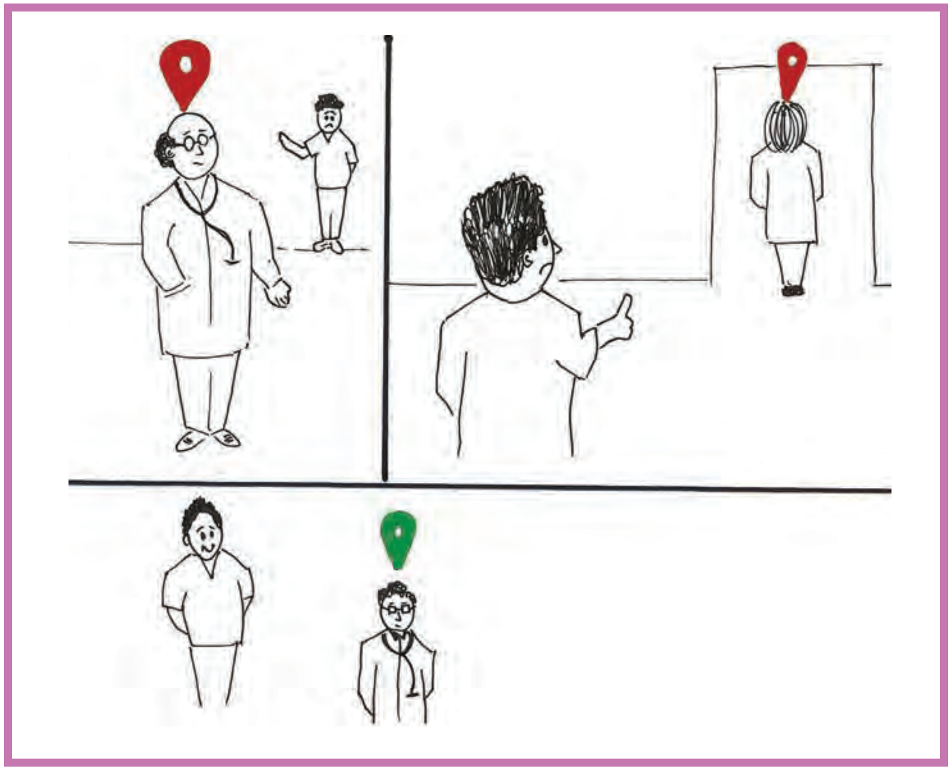
1. Locating people and determining interruptibility
2. Sharing cases quickly and easily
3. Increasing productivity by utilizing downtime

The next few pages explain each of these scenarios in more detail. These are merely starting points for a discussion about what the final product could be. We will refine these further with the help of our client representatives at GE Healthcare.

SCENARIO

Scenario 1: Use hotspots to track locations

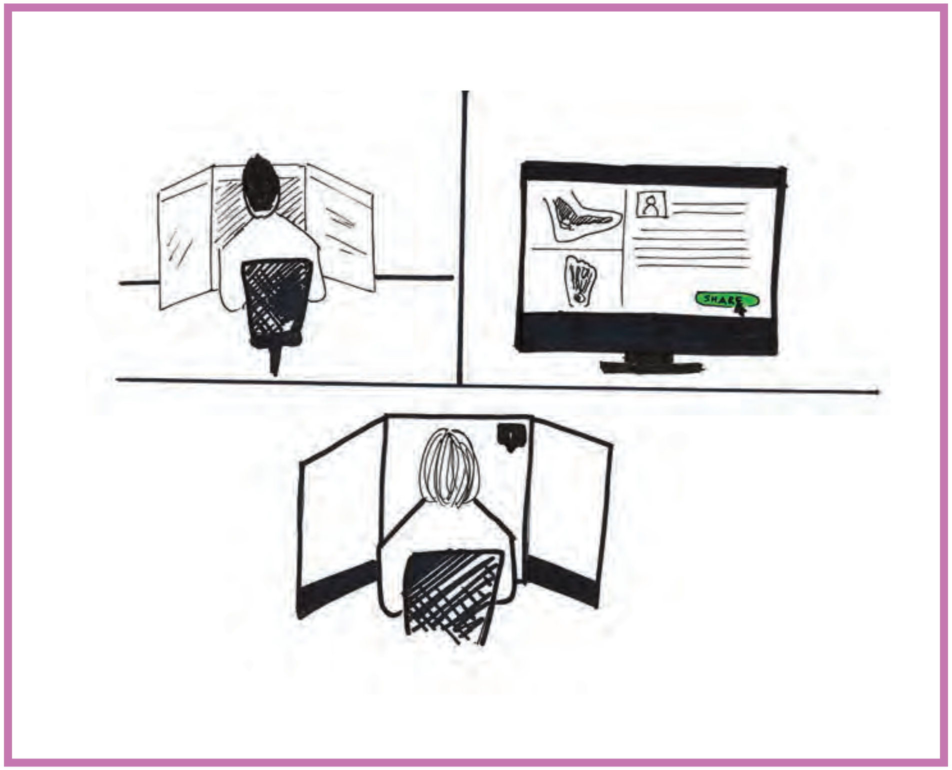
In this idea, we suggest creating wireless hotspots that link up with a radiologist's smartphone and provide an approximate idea of his location within the hospital. A single hotspot would be used to serve an area such as the cafeteria or the reading room. Each hotspot would have a different and unique electronic signature, making it easy to track where the radiologist or physician is.



Scenario 2: Share cases with others

Radiologists need to collaborate with each other from time to time on a particular case. In most cases, they use the phone or interrupt each other in person. Some interruptions are extremely important as they might pertain to emergencies while some are requests for second opinions or to discuss a less critical aspect of a case.

The medical record is the only way to share case information and is inefficient. The images are stored in the PACS while the medical record is located on another system. We suggest creating an asynchronous channel dedicated to sharing cases using “Case Links” which would provide direct access to a case in the PACS.

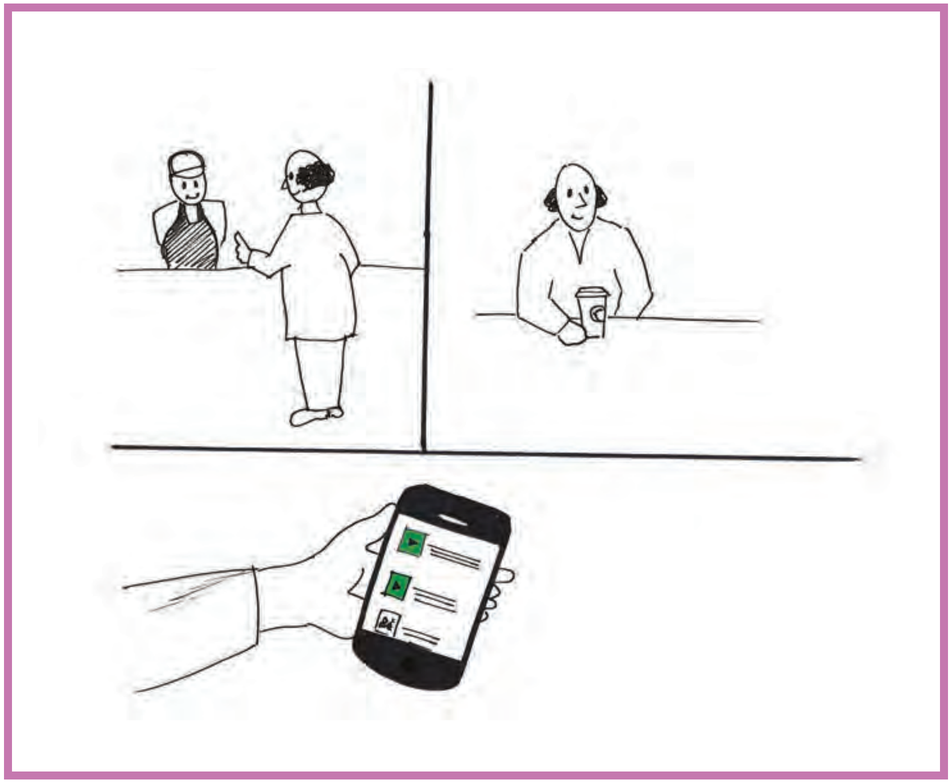


Scenario 3: Utilize downtime to be more productive

We use “downtime” to refer to time spent away from reading cases. Radiologists often take breaks or cannot read cases, for example, if their system has crashed. Downtime happens often and can be used more effectively.

During downtime, radiologists could study or watch video tutorials created by colleagues. The radiology department could develop a repository of tutorials and academic articles.

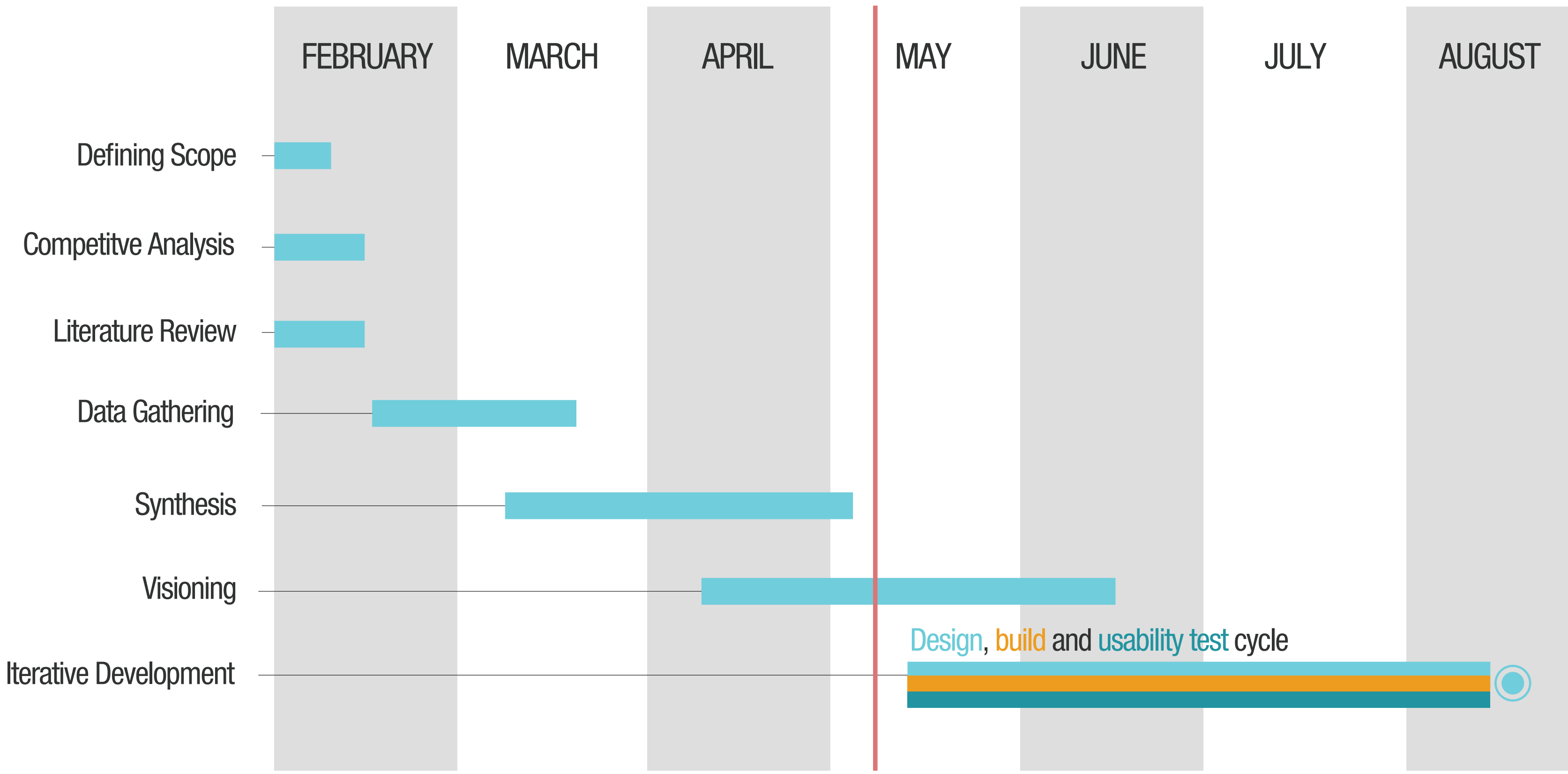
Radiologists could access this repository using their smartphones, learn to solve problems they face daily, and stay more informed about current trends in radiology. This system could also be used to train residents, allowing attending radiologists more time to read cases.



NEXT STEPS

OVERVIEW

Between mid May and early August, Shoal will work with GE Healthcare to solidify our visions and to select one to evaluate and prototype. In August, Shoal will deliver a final report, design specifications, and a high-fidelity interactive prototype GE Healthcare can use as a guide to developing a working product and as inspiration for related products.



DOMAIN KNOWLEDGE

LITERATURE REVIEW

OVERVIEW

The following is a summary of twenty of the most important papers from our literature review focusing on collaboration, interruptions, and areas of future growth in radiology. Some of these papers explored these aspects in domains besides medicine and radiology and provided valuable insights into the nature of cooperative work.

Works cited are listed in the Appendix.

Mobile communication and diagnosis is an emerging area in radiology.

Hospitals are task-driven environments and involve much multi-tasking and task-sharing. This raises several design challenges, particularly in integration and mobility. Increasingly, workers complete tasks using mobile tools in coordination with situated ones. Tasks can be implemented as concepts to coordinate between people, systems, and devices. [1] Tasks may involve activities, images, actions, operations, contexts, and actors. [2] While this metadata is sufficient to communicate work between remote workers, notable integration issues emerge with regard to designing solutions for the medical environment, where even necessary interruptions can be costly. [4] To reduce unnecessary interruptions, it helps to see the trajectory of a hospital's working parts as they relate to a single task.

Some types of communication require face-to-face interaction between stakeholders to coordinate a specific patient's diagnosis and care.

Today, such meetings require stakeholders' physical presence. However, research in developing groupware to allow remote meeting participation resulted in investigations of multi-display, multi-device systems, shared gestures, and shared screens. [5] The research also investigated digital analogues of pointing and marking images during meetings. Lack of support for high-resolution image transfer prevents wider use of audio/videoconferencing for groupware radiology discussions.

LITERATURE REVIEW

Studies of the social context of mobile usage reveal privacy and security issues, particularly in a workspace.

Radiologists collaborate in person and using landlines, cell phones, and other communications tools. Social and professional spaces blend together, possibly causing interruptions to task workflow. Landlines and cellphones compete with medical images for attention and often disrupt the primary user's concentration as well as that of secondary users in a shared physical space. [6]

Groups working together are more resilient to interruptions and stay on task for longer periods than individuals.

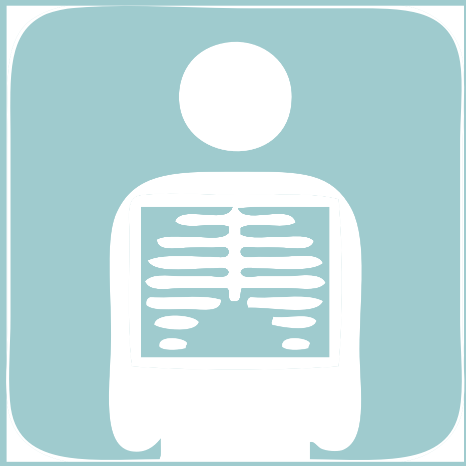
It would be worth investigating if this rationale also applies to radiology. User interfaces can be designed to aid in recovery from interruptions by presenting temporal cues to their users. Existing PACS systems could be redesigned on this basis. [7, 8, 9, 10]

Decision-support systems and electronic medical record data within the radiologist's RIS workflow can result in better patient diagnosis.

Also, e-learning has been shown to be effective in teaching residents and medical students about radiological procedures. [12,14,15]

Teleradiology is already widely employed.

50% of hospitals and 75% of radiologists use some form of teleradiology service, particularly for computed tomography scans. 500 teleradiology firms provide real-time consultancy services, and telehawk (nighttime) services are highly profitable. More widespread availability and integration of PACS, RIS, HIS, EMR, imaging, and reporting standards should accelerate this trend—research indicates that systems integration is the biggest barrier to entry and adoption of teleradiology. Legal and protectionist issues as well as concerns about quality of care are secondary barriers. However, other studies indicate that teleradiology could provide specialized care where it might not otherwise be available. [11, 13, 14, 16-20]



COMPETITIVE ANALYSIS

OVERVIEW

Telemedicine is an growing market in the healthcare industry. Over the last few years, smaller companies with a focused vision and problem specific solutions have emerged as forerunners in this field. In our competitive analysis, we looked for companies or products that facilitated communication and collaboration in healthcare or delivered cutting edge solutions through innovative designs.

All the products in our competitive analysis solve specific problems faced by medical professionals. Unlike larger products (such as HIS or a PACS), they are focused. That is the major reason behind their success.

Our complete competitive analysis is in the Appendix.

Vocera

Voice communication badge for healthcare

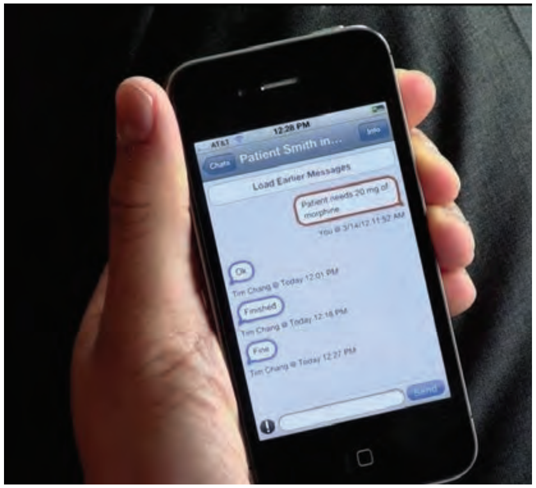
Key features

a. Hands-free operation
b. Small form factor pins to lapel or pocket
c. Recognizes voice commands
d. Runs over hospital's wireless network
e. Special encryption techniques make this HIPAA compliant
f. Supports smartphone integration

Why it works:

Vocera targets a very specific problem observed throughout hospitals: getting hold of people. The form factor is ideal for being pinned onto a lapel or a collar and works non-intrusively. Its hands-free operation makes it convenient for the healthcare environment. It replaces pagers and reduces dependency on landlines.

COMPETITIVE ANALYSIS



Medigram

HIPAA compliant messenger for healthcare

Key features

a. Uses 256-bit encryption
b. Simple and easy to use, just like texting
c. Chat with one person or a whole group
d. Runs on iPhone and Android

Why it works:

Medigram uses the simplest medium for communication: texting. It makes text-based messaging secure and HIPAA compliant. You can add an entire team of people and categorize conversations based on patient names or ID's. It caters to a growing desire for smartphone usage in hospitals. Future plans aim at integrating voice and data.

MIM Software

Radiological imaging software for iPhone/iPad

Key features

a. Support a variety of image modalities
b. Secure cloud-based storage for archiving images
c. Desktop-based tools provide improved visualizations and analysis
d. A special version of the app allows patients to save their records

Why it works:

MIM Software started out with a simple application for viewing medical images on the iPhone and have since extended their suite of applications. Their desktop applications allow radiologists to visualize and analyze images more effectively, for example, via automatic seed location and dosage visualization. Patients can save their medical images on their mobile devices while the version for doctors has a richer feature set. They provide a secure cloud based service to store medical images as well.

COMPETITIVE ANALYSIS

PeerVue QICS

Collaborative peer evaluation tool for radiology

Key features

a. Shared workspace for the peer review process
b. Pulls data from PACS, RIS and HIS
c. Configurable interface caters to individual needs
d. Data logging for JCAHO
e. Quick access buttons for frequently used functions
f. Asynchronous messaging

Why it works:

Simplifies the organization of peer review process, which involves sifting through a long work list to identify cases and assigning them to different people. Using QICS (Qualitative Intelligence Communication System), you can specify criteria to filter your work list automatically. It will even suggest possible assignments. This reduces a lot of work and is completely paperless compared to the standard approach.

QICS utilizes asynchronous messages to indicate cases under review across multiple workstations and logs the results of the peer review process in compliance with JCAHO.

ABOUT THE PROGRAM

ABOUT THE HCII

OVERVIEW

The Carnegie Mellon Human-Computer Interaction Institute is an interdisciplinary community of students and faculty dedicated to research and education in topics related to computer technology in support of human activity and society. The Master's program is a rigorous 12-month curriculum in which students complete coursework in programming, design, psychology, HCI methods, and electives that allow them to personalize their educational experience. During their second and third semesters, the students participate in a substantial Capstone Project with an industry sponsor.

The Capstone Project course curriculum is structured to cover the end-to-end process of a research and development product cycle, while working closely with an industry sponsor on new ideas that may work with their existing human-to-machine technology. The goal of this 32-week course is to give each student the opportunity for a "real-life" industry project, similar to an actual experience in a research/design/development setting.

Company sponsors benefit from the innovative ideas produced by the students, to fix existing systems or reach into new markets. Some companies also use this project as a recruiting tool, offering industry positions to the top producers in their project team.

For questions about the content, or to learn how to sponsor a project please contact:

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Human-Computer Interaction Institute
Carnegie Mellon University
Pittsburgh, PA

Masters Program Director

As the Director of the Masters Program, Jenna Date works with faculty, staff, alumni, and current students to create a rigorous, engaging and rewarding experience for each incoming class of students. Prior to the Directorship at MHCI, Jenna co-founded Fit Associates, LLC. Fit's intention is to lead, nurture, connect and equip conscious clients for the greatest impact for the common good.

Industry Mentor

David Bishop is a MAYA Fellow in Human Sciences and a senior designer & researcher. He focuses on assisting MAYA's clients to improve their practice of human-centered design (HCD) and elevating their level of maturity with respect to designing user experiences. David's priorities include metrics for continuous improvement as well as usability metrics for efficiency, effectiveness, and satisfaction.

ABOUT THE TEAM

Design Lead

Christian Park holds a degree in Industrial Design from Carnegie Mellon University and has worked for companies such as Proctor & Gamble and General Motors.

Technical Lead

Asim Mittal holds a degree in Electronics Engineering from the University of Pune, India. He used to build electric cars in a past life and now leads his own tech startup.

User Research Lead

Mahvish Nagda holds a degree in Computer Science from UIUC and worked as a software engineer for five years in the finance and government sectors.

Project Manager

Russ Essary studied Philosophy and Anthropology at New York City's Fordham University and previously worked with assistive speech technology maker DynaVox.

APPENDIX

On Disc:

Field guide
Transcripts
Data models
Literature review
Competitive analysis
Data buckets

Shoal

GE Healthcare | HCII Carnegie Mellon | May 7th, 2012