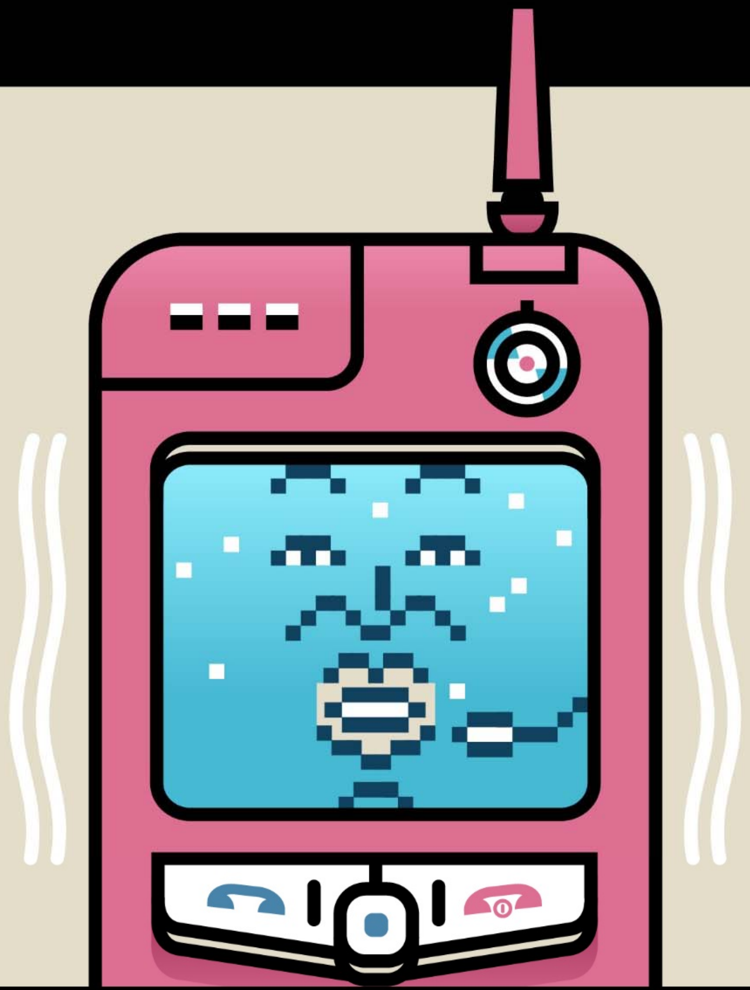
IVR

SYSTEMS & TECHNOLOGY



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Contents

1 Interactive Voice Response Systems

Interactive Voice Response (IVR) is an application that allows a combination of voice input and touchtone keypad selection and responds in the form of callback, voice, email, fax, or perhaps other media, depending on what it is programmed to do. IVR applications utilize the omnipresent telephone infrastructure to provide information availability 24 hours a day, seven days a week. The ease of set up and high availability make it cost-effective for businesses.

2 History & Evolution

Technology is changing the way people live. Computers have become more sophisticated, more prolific, and less expensive. Computers should make life easier, more satisfying, and better in general. Otherwise, what would be the point in using technology? In many instances, computers have performed up to expectations. It would be hard to go back to life without word processors, electronic mail, or spreadsheets. Computers have made it possible to search the Internet for information on billions of web sites in only a few seconds using a search engine such as Google. Computers are embedded in many everyday appliances that users do not even think about, such as microwave ovens and automobiles. Computers operate traffic lights and have made eBay possible.

Users sometimes mistakenly think that improved technology means greater ease of use. All one has to do is look at some counterexamples of less user-friendly technology: the increasing number and complexity of remote controls for television and stereo equipment; cell phones and personal digital assistants (PDAs) with so many features that many people do not make use of all of them. Personal computers present their own set of frustrations. Technology should not just get more complex, it should be easier to navigate. Otherwise, why bother inventing things that people do not want to use?

One application that seems to stand out as an unhelpful use of computers is one that most people have difficulty avoiding. Interactive voice response (IVR) is a computer technology that has been changing the way people use the common telephone since the late 1970s. A computer-generated human-sounding voice answers rather than a live person. The caller hears a list of options and chooses by pressing one of the keys on the telephone keypad. Over the last few years, there have been a wide range of applications of IVR systems in which the telephone is used for information exchange via a computer, including the following: bank-by-phone, voice mail, menu systems for routing service calls, job lines, and voice recognition systems. The success of such systems depends on the usability of the interface and interaction, particularly adequate levels of performance, as well as adequate levels of user satisfaction. A relatively small proportion of the research in the field of human computer interaction has been devoted to adopting principles and guidelines for the development of usable IVR systems.

3 DTMF vs. Speech Recognition

Dual Tone Multi-Frequency (DTMF) is also known as Touch-Tenet™. DTMF represents the technology of phone-based interfaces that rely on the caller to select an option by pressing a key on the standard telephone keypad. Automatic Speech Recognition (ASR) refers to the phone-based interface that allows the caller to speak into the telephone handset to select an option or request service. ASR is only beginning to be used on a limited basis. Here is a discussion of some of the limitations of ASR and justification for using DTMF.

Automatic speech recognition interfaces have not been implemented on a large-scale yet for several reasons including cost and the high rate of errors by the recognizer. The recognizer is a computer that uses pattern-matching algorithms to endeavor to categorize similar patterns independent of the speaker. A statistical model uses the frequency of phonetic make-up of the speech input to analyze the meaning. In a system that accepts a limited number of speech inputs, the recognizer does well. If the number and type of speech inputs are not limited or specified, the recognizer may make many errors.

Callers often do not know what response is expected of them and what the recognizer is capable of doing. For callers with a dialect, foreign accent, or speech impediment, ASR systems may not be accessible. Speakers may be calling in a noisy environment or one that does not afford them needed privacy. If the computer voice sounds human, might not the callers assume it could understand like a human? The 'How May I Help You?' experimental interface by AT&T is especially problematic in this regard. How does the caller know what to say?

Susan Boyce discussed the pros and cons of natural language dialogues in an article in *Communications of the ACM*. She examined how human-like the computer voice should be: should it have personality, and how do callers know it is a computer? Results of her study indicate that callers prefer a casual system referring to itself as "I." The initial prompt will let the caller know that a computer is answering the telephone either by explicitly stating that fact or by having a somewhat robot-like voice speak the prompt. Several hurdles must still be overcome, including real-time processing of complex algorithms. This requires expensive processing hardware, but will become more affordable in the future. Another task is to find appropriate applications for ASR that do not require 100% accuracy.

Ben Shneiderman contends that speech recognition has limited application because of the way acoustic memory and prosody work (prosody refers to the "emotional" quality of spoken words). Humans think in an acoustic mode. Speech input interferes with that. The human-human interface is quite complex, and qualities of the voice, such as intonation and pacing, give meaning to the actual words spoken. A rising tone at the end of a statement indicates a question. Still, for some interfaces, speech may work. A more significant problem is that spoken language interferes with short-term memory. In an experiment to determine whether some advantage exists for speech versus mouse commands for word processing, researchers found that in the case where short-term memory was important, speech interferes.

"The problem of knowing what to say to a speech application has two components. Users can assume the computer will be able to understand more than is actually possible, and users can be unaware of functionality that is available" (Yankelovich, 1996, p. 35). The constraints on a speech system include the support of a large vocabulary with accuracy. Continuous speech is more difficult to recognize than discrete speech. Humans tend to run their words together, yet are perfectly understood by other humans. The user may have to speak in an unnatural way for the recognizer to understand the input. In an article published in *Transactions*, called "How do users know what to say?", Yankelovich collected suggestions for improving the ASR interface from user interface designers in several large telecommunications organizations including Adam Cheyer and Patti Price from SRI Artificial Intelligence Center, Stephan Gamm from Philips Research Laboratories, Francis Ganong from Kurzweil Applied Intelligence, Jim Glass from MIT Spoken Language Systems Group, Candy Kamm and Amir Mane of AT&T, Demetrios Karis of GTE, and others. Most agree that the key is developing the prompt. One designer, Troy Kamphuis of Nuance Communications, suggests three types of prompts from implicit to explicit, ranging from poor to best.

- *Spoken prompt 1*: "Welcome to ABC Bank. What would you like to do?"
- *Spoken prompt 2*: "Welcome to ABC Bank. You can check an account balance, transfer funds, or pay a bill. What would you like to do?"
- *Spoken prompt 3*: "Welcome to ABC Bank. You can check an account balance, transfer funds or pay a bill. Say one of the following choices: check balance, transfer funds, or pay bills."

It seems simpler and less costly to have an interface that might sound like this:

- *DTMF prompt*: "Welcome to ABC Bank. To check an account balance, press 1. To transfer funds, press 2. To pay a bill, press 3."

4 Common Applications

4.1 IVR in Banks

Interactive voice response (IVR) systems have come a long way to offer solutions for the purpose of reducing customer support costs. IVR systems allow banks and similar organizations to offer their services without the help of a human representative, thus reducing the need for customer support staff. IVR can also provide cost effective alternatives to accessing banking information, completing financial transactions, and phone-based shopping, etc. The recognition of IVR in financial organizations such as banks is primarily due to the fact that it can be used by anyone from anywhere, offering universal access that distinguishes the type of device the user has.

4.2 IVR in the Health Care Community

An IVRS is information technology that links a person with a computer database via a telephone. Upon each telephone call, the IVRS can deliver medication and appointment instructions while the patient can respond to questions verbally or by pressing the appropriate numbers on the telephone keypad. The IVRS telephone messages are automated and the system can be programmed to continue to call a patient until they have been reached. Therefore, the delivery of information is not influenced by the workload of health care professionals. Without having to call patients, health care professionals are available for other tasks.

IVRSs are increasingly being used by health care institutions for disease screening (e.g. depression), disease symptom monitoring, behavior monitoring (e.g. substance abuse), conducting behavioral counseling, assessing medication adherence, and increasing appointment compliance. Friedman et al. (1996) reported that patients monitored by an IVRS for hypertension showed a 6% improvement in mean adherence to antihypertensive medication compared to patients receiving usual care. Feldstein et al. (2006) demonstrated that patients who received an automated voice message reminder were significantly more likely to complete recommended laboratory monitoring than patients receiving usual care (HR 4.1 95% CI 3.0-5.6). Forster and van Watraven (2007) highlighted the utility of an IVRS in improving post-discharge monitoring.

A number of health information systems have been used to communicate oral anticoagulant (OAC) information to patients, and three studies have used portable devices that are connected to anticoagulation clinic databases using the internet. The HAT (home automated telemanagement) system records self-monitoring patients' INR results in a home unit device. Data is transmitted to the clinic where a physician reviews the information and forwards their instructions back to the patients' home unit device. Compared to these systems of anticoagulation management, an IVRS is primarily appealing because of its generalizability. Patients can be monitored by an IVRS without being self-monitored or requiring email or cellular telephone access. An IVRS called INR RELAY has been used to communicate with OAC patients. INR RELAY was developed in 2000 by staff at the anticoagulant clinic of the Pathology Department in Basildon and Thurrock NHS Trust. On a daily basis, the clinic sends a report of patients' latest medication and appointment instructions to INR RELAY service staff. The service staff then programs the calling system to deliver the automated telephone calls. INR RELAY also calls patients if they miss an INR appointment. In 2000, staff at the clinic conducted an observational study and concluded that both patients and staff were satisfied with INR RELAY (Cervi, 2006).

5 Attitudes toward Interactive Voice Response

Boren (1993) conducted a survey to measure attitudes toward IVR. According to his findings, attitudes were somewhat negative toward the use of computers to answer the telephone. Remarks to the researcher were of two kinds. (1) The technology is new; surely it will get better. And, (2) voice recognition will replace key entry within a few years.

Two earlier studies were done in the 1990s to examine the acceptance of Interactive Voice Response Systems. One survey included 800 adults (Settle, Dillon, & Alreck, 1999) and the other included 912 adults (Katz, Aspden, & Reich, 1997). Both surveys used an extensive list of statements that respondents answered by indicating how much they agree or disagree with the statement by marking on a five-point Likert scale. The study by Settle et al. employed a convenience sample using students to deliver and collect the self-administered questionnaires from shopping malls, neighborhoods, etc. An effort was made to sample equal numbers of men and women and participants from each decade of life from the twenties to the sixties. The results indicated that only one variable, age, made a significant difference. The older participants had more negative attitudes to IVR.

In the study by Katz et al. (1997), a survey questionnaire was sent to a random sample of 5,000 names and addresses across the United States. Thirteen percent were returned because of address problems. Response rate was 21% or a total of 912 surveys returned. The respondents were not truly representative of the population as a whole since the lower income groups were excluded because of address problems. Nevertheless, the researchers felt that this study was a good exploratory measure of attitudes toward IVR systems. They found that the two most significant predictors of liking IVR systems were experience with the last electronic system encountered and age. Women liked IVR systems more than men, young did more than old. Education or income level did not yield significance for liking IVR. The results from Katz et al. are summarized in Table 1.

Table 1. Results for Electronic Voice Response Systems (Katz et al., 1997, p. 134)

	Gender	Age	Education Level	Income Level
Liking for	Women > Men	Young > Old	High = Low	High = Low
Frustration with	Men > Women	Old> Young	High = Low	High > Low
Found convenient	Women = Men	Young > Old	High > Low	High > Low

There is a need of research to find a way to improve the technology interface so that it could better serve everyone, including members of the older generation. All users will ultimately benefit from designs that are better for older adults (Vanderheiden, 1997; Vanderheiden, 1990). The 2000 census for U.S. households showed that the highest median net worth was for people in the 70 to 74 year age bracket. The message to marketing is that older consumers have plenty of money to spend. Products used to be targeted to a much younger age group. But ads now feature actors with grey hair promoting cars and electronic equipment (Greene, 2004).

6 Voice vs. Visual Interfaces

Interactive voice response systems pose many usability challenges due to the nature of the interaction. IVR is a serial, temporal, and continuous interface dependent upon voice and audio cues. These limitations are best seen in juxtaposition with visual interfaces.

Voice interfaces involve a dynamic, sequential, and temporal presentation of information, in which each piece of information is "removed from usable access very rapidly" and replaced by another piece of information (Muller and Cebulka, 1990). According to Muller and Cebulka (1990), the major difference between voice and visual interfaces is that navigation in a voice interface consists of going forward and backward and is nowhere near as rich as with visual interfaces.

With visual interfaces, a great deal of information can be presented simultaneously (Muller and Cebulka, 1990), with the capability of using various dimensions to present information. These dimensions include size, shape, color, shading, and others. Voice interfaces, on the other hand, are limited to serial presentation of information and a very different repertoire of methods for transmitting that information. For example, audio cues can be used to denote relative distances or boundaries of images, and voice quality can be varied in terms of gender and pitch to relate moods and intentions. As Stevens (1993: p. 179) points out, the ''human visual system is adept at quickly, holistically viewing an image or a page of text and finding a desired piece of information….On the other hand, objects that have intrinsic constant temporal rates such as audio and video are difficult to search." Indeed, Resnick and Virzi (1993: p. 421) identify the temporal presentation of information as the critical factor which distinguishes their "analysis [of IVR interaction styles] from analyses of most visual menus and forms."

7 Short-Term Memory Constraints

The memory demands of voice and audio interfaces are higher than for visual menus. Visual interfaces allow for a greater number of cues and provide the user with the opportunity to refresh their memory by glancing at a screen on which a large amount of information is being presented simultaneously. Voice, however, is serial and temporal, with limited navigation and presentation capabilities that require the user to hold task-related information in short-term memory that is already full of information concerning their location and options in the voice interface.

Hart & Staveland (1988: p. 141) defined the notion of workload as "a hypothetical construct that represents the cost incurred by a human operator to achieve a particular level of performance." Given the constraints placed on a user by an IVR system, mental (or cognitive) workload can be said to be high, specifically with reference to short-term memory, and the "limitations of human processing capacity" (Waterworth, 1985: p. 221). Edwards (1988) corroborates this conclusion by stating that most of the problems encountered by users in his studies on audio and voice interfaces were related to the extra load imposed on the user's memory. The demands placed on short-term memory by voice interactions can also curtail exploration of the IVR system (Bradford, 1995), thus inhibiting learning and consequently reducing usability.

The short-term memory constraints also have implications for the types of errors likely to be committed during an interaction with an IVR system. Huguenard et al. (1997) identify two main classes of errors associated with phone-based interactions that occur due to demands placed on short-term, or working, memory. The first class of error includes those related to information loss in which users forget information needed to complete a task caused by limitations in STM capacity. The second are choice errors in which the user selects the wrong option when presented with a set of choices. Choice errors are closely tied to navigation through the voice application, especially menu-based IVRs and reflect getting lost or losing sight of the goals of the interaction.

Voice interfaces place extra demands on short-term memory due to limitations in navigation and simultaneous presentation of information. These demands increase the likelihood of errors and the perception of cognitive workload. These challenges to the usability of IVR systems may be addressed by optimizing the design of file interaction to minimize errors and workload, and by providing designers with guidelines and standards to enhance the consistency of IVR systems.

8 What about Guidelines or Standards

Experts in interactive voice response and human factors have been calling for the development of standards. The process is slowed by several factors. IVR research in academia is sketchy. With notable exceptions, very few papers have been published on IVR standards or guidelines (Buie, 1999; Gardner-Bonneau, 1999; Virzi & Huitema, 1997). Another reason that IVR guidelines are not available is that the telecommunications companies that perform research are unwilling to share their data. A third reason is that the existing IVR systems are inconsistent (Killam & Autry, 2000). The idea of getting everybody together and agreeing on standards is quite likely a pipe dream.

More realistically, several human factors practitioners have proposed guidelines developed from their knowledge of human factors principles. Killam & Autry (2000) were asked to improve a working interface. In an experiment, the research team did usability testing with 32 participants comparing the working interface to the proposed improved interface. Ninety percent of the participants preferred the new interface although they did not know either interface was currently being used. Participants were able to navigate the improved system faster and with fewer errors. As a result of this study, Killam proposed a list of guidelines which are listed in Table 2.

The researchers found some positive results for using these guidelines to improve an existing interface. They were tested as a whole so nothing could be inferred about an individual guideline. Some of the guidelines in Table 4 make sense; some do not. For example, referring to guideline #6, would providing a pause be enough or even appropriate to encourage early selection? Killam may have been trying to provide menus with fewer options in order to preserve the capacity of short-term memory (STM). In fact, the experiment in the present research shows that an additional item does not interfere with STM. Callers may prefer to have the list continue to the end rather than pausing. Guideline #9, offering an option to pause the system while additional information can be obtained, does not seem to have caught on. Most callers should either be prepared or should hang up and call again with the needed information. It might be helpful to tell the caller what information they should be prepared with right away so they do not have to listen to the menus and then find out that they need to hang up and call back with the information.

Guideline #13 is directly counter to good human factors practice. Reading back a social security number or credit card number without the pauses would make it more difficult for the caller to confirm the correct number. Most people think of those numbers as chunks rather than a string of nine or sixteen numbers. Perhaps individual guidelines need to be tested. What seems obvious to one human factors professional may seem incorrect to another. It would seem that the prudent thing to do would be to design an interface and do usability testing on it. Guideline #7 requires an explicit action for all menus rather than allow no action to be an assumed selection. Many callers hope that by not making any selection, they will be connected to an operator. Except in rare cases, an operator should be available. Having an operator available conforms to guideline #2 which says that the system should be optimized for caller-efficiency rather than for software efficiency. Guideline #8, the option to cancel the choice and return to the previous menu, seems reasonable and, in fact, desirable. The other guidelines seem to have merit.

Daryle Gardner-Bonneau agrees with Killam that guidelines can be developed using human factors expertise (Gardner-Bonneau, 1992; Killam & Autry, 2000). Gardner-Bonneau presented a pivotal paper at the 1992 meeting of the Human Factors and Ergonomics Society, entitled Human Factors Problems in Interactive Voice Response (IVR) Applications: Do We Need a Guideline/Standard? She suggests that many of the problems in IVR systems are a result of poor scripting or dialogue design. Other problems occur because IVR is used in applications that do not lend themselves to the technology. Businesses that implement IVR are often on their own in developing the scripting and routing of calls. The person who implements the interface is most likely not a human factors specialist. The application is driven by company needs rather than by caller needs.

Most of the problems related to the IVR interface could be avoided with the careful application of human factors principles (Gardner-Bonneau, 1992; Killam & Autry, 2000). Developing a standard for IVR is a challenging undertaking. Yet the application developers need guidelines in order to provide acceptable and efficient interfaces for the users. Gardner-Bonneau recommends several groups that could undertake this project. The logical first choice is the Communications Technical Group (CTG) of the Human Factors & Ergonomics Society. The CTG has a diverse membership representing telecommunication companies and other businesses. The American Voice Input/Output Society (AVIOS) may provide some support but does not have the human factors representation to accomplish the task.

Table 2. Guidelines for the Design of IVR Systems Developed by Killam (2000)

1. Develop and maintain a consistent mental model of the system for design and operation, how the system should be integrated with other IVRs within the same organization, and how the system should be integrated with other forms of customer support (e.g., web, email, and post).
2. The system should be optimized for caller-efficiency rather than for software efficiency.
3. Provide a simple greeting and a high-level main menu before proceeding to the caller's issue to ease the caller into the participant matter.
4. Provide both location and progress feedback by announcing the name of each menu before giving the options.
5. Present menu options in "specific-to-general" order to avoid callers picking a broad category before hearing a later, more specific category.
6. Provide a pause in each menu after the substantive options and before the general options (e.g., "To repeat the choices press ... ") to encourage early selection in menus.
7. Require an explicit action for all menus rather than allow no action to be an assumed selection.
8. Provide the ability to cancel the last menu selection and return to the previous menu.
9. Inform callers about information they will need to complete a transaction at the top of each application and provide the ability to "pause" the system to get this information as well as the option to hang up and call back when the information is obtained.
10. Use inflection to highlight distinguishing information in explanations and menus that are similar.
11. Use timeout for user data entry but also accept caller-entered terminators.
12. Use consistent wording for all confirmation messages to encourage cut through.
13. Read back user entered data confirmation quickly and without formatting information (e.g., simulated pauses in a social security number).
14. Design the most frequently used path through the system to use the first, or earliest menu choice possible.
15. Provide a streamlined path through the system, where possible, by allowing repeat callers to bypass explanations and other non-essential information.

Perhaps standards are not what is needed, after all. In this example, Schumacher, et al. (1995) relays the following example from a current ISO/IEC voice-messaging standard.

The star key is used to bring the user to a control menu. The control menu contains several options. The user can press 7 to return to a main menu, 9 to force a disconnect from the interactive voice response system, 0 to get help, and # to exit the control menu and continue forward in the interface from the state the user was in prior to reaching the control menu. Pressing * again in the control menu will either (1) cancel the current entry in progress and issue the prompt played prior to the entry, if the user was in input mode (entering data into the system before reaching the control menu; or (2) revert to the beginning of the current output, if the user was in output mode (receiving data from the system) before reaching the control menu. (1995, p. 255)

This standard seems unnecessarily complicated to the point of being ridiculous. One of the guiding principles of human factors is to keep it simple. Schumacher, Hardzinski, & Schwartz (1995) suggested that the lack of published guidelines contributes to the variability in the quality of phone-based interfaces. They went on to present what guidelines, standards, best practices, and empirical research was available at publication in 1995. However, the point is that there is no universal agreement on standards. Every system a caller comes across is a new interface.

9 Future Directions

Interesting uses of IVR technology besides voice mail and automatic call directing have been developed. Some of these auditory interfaces include psychological screening and assessment, access to information about government services and matters, self-management of employee investments, and providing access to graphical user interfaces and scientific instruments to the visually impaired. IVR systems are ubiquitous and will continue to be so.

In a number of surveys, the attributes of age, gender, experience, and cognitive styles were identified as characteristics that are likely to affect performance and satisfaction with IVR systems, either overall or in response to particular interaction styles. The audience or intended user population for an IVR system may be general or clearly identifiable. If the population is general, then the interaction should be designed to be usable to either the lowest common denominator or the widest scope. If the user population is clearly identifiable with relatively fixed characteristics or parameters, then guidelines about usability requirements of those users would be most valuable in developing an optimized IVR system. Another way knowledge about the demographics and experience level of the user may be taken into consideration is in the use of profiling.

Furthermore, there is a role for IVRSs in the health care community, but the technology must be optimized before such organizations invest in it and implement it on a larger scale. First, the automated dialogues must be carefully designed and periodically refined. Health care institutions should collect and review patient feedback on the IVRS dialogue. Simple dialogue is essential for effectiveness. Second, IVRSs should be programmed to re-attempt 'failed' calls after a couple of hours have passed. Finally, an IVRS should allow users to select the telephone number that will be used to contact patients. This option would improve staff usability. Nonetheless, implementing health information technology is challenging and requires cooperation between the technology company and the health care institution. Dedicated and adaptive staff members from both parties are essential to designing, implementing, and evaluating this technology.

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