Audio Autonomy

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1.0 Introduction

We have designed and built “Audio Autonomy,” a proof of concept that shows the capabilities of an audio system for dementia patients and their caregivers. It is meant to provide safety, comfort, and delight, with support for many activities of daily living (ADL). It illustrates just one component of more advanced personal health care companions and gerontechnologies that are now being described as “Ambient-Assisted Living” (AAL).

The audio system goes in the home, and is managed by the caregiver using a web interface. It resembles the ship’s computer on Star Trek, or HAL 9000 of 2001, in that it behaves like a computer whose main interface is audio. From the patient’s perspective, it listens, and can talk or play music. It is an “audio assistant” of sorts. It can respond to commands, music requests, and questions. It also plays scheduled music, voice interactions, audio content, and potentially interactive “mini-programs.”

The caregiver uses a website scheduling calendar to curate all the activities, including music and question-answer responses. For the caregiver, it offers support and stress relief. Ideally it

will help prevent caregiver burnout, which often results from the fatigue and stress that comes with guiding an aging loved one through dementia care.

Uses of Audio Autonomy include:

- answering questions that get asked repeatedly
- playing music to build routines and facilitate challenging transitions during the day
- reminders for medication, daily tasks, and safety
- delightful and engaging music, ambient sounds, or audio content
- supplementary emergency response service
- phone fraud prevention training
- time reminders
- invitation prompts to choose personally curated audio content

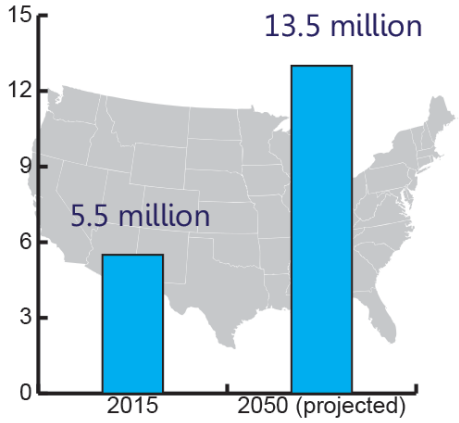
As a proof of concept, we are demonstrating an experience architecture. It relies on a technical architecture to show feasibility, and a possible prototype for user feedback, experimentation, and testing. The technical architecture could potentially be redesigned to support either the existing experience, or future modifications.

2.0 Meeting a Need

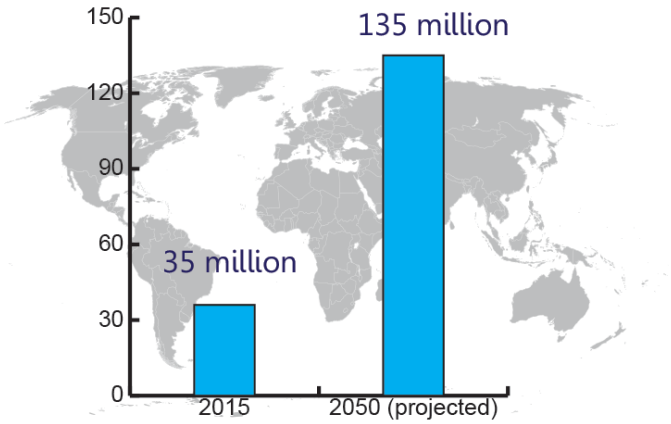
As people live longer the population grows and becomes older, global dementia cases are on track to triple in size by 2050. About 35% of all people 85 or older will have some form of clinical dementia. This creates a huge crisis in personal lives and economies. Prevention and care of every kind will be needed.

Number of People with Dementia (in millions)

US



Global



Dementia patients have both critical needs and quality of life needs. Caregivers also have support needs, since caring for dementia can be exhausting, leading to high rates of burnout and depression among caregivers. For patients, caregivers, and also health care systems, independent living has many medical, emotional, quality-of-life, and financial benefits. Our system seeks to enable independent living to meet both caregiver and patient needs. It also contributes specifically to help calm or engage the patient in the ongoing struggle against agitation, anxiety, confusion, depression, and anger.

The support of calmness vs. agitation, of creating comfort vs. distress, is a guiding design agenda for patient dementia care. Caregivers also need calm and stress reduction. We seek to help caregivers design the care activities and experiences.

3.0 Research Areas

Automating, and structuring experiences and routines for patients is desirable in many ways, because regularity and repetition help with anxiety and the specific distresses of the disease.

When creating Audio Autonomy we had to contend with:

1) long-term ongoing decline over patient lifespan, which means continuing adaptation
2) high levels of personalization, since individual dementia cases vary highly
3) daily creating structure, routines, and transitions amidst unpredictability
4) a wide range of experiential stimuli and environmental factors for the patient

There are many types of audio experience that can help delight or calm patients, alleviating dementia symptoms, through voice interactions, music, reminders, audio content, and even ongoing learning and training to help with challenges to their safety, comfort, and activities of daily living(ADL). “Audio Autonomy” is just one component.

In light of the complexities mentioned, our system needed to be designed differently than Apple’s Siri or Amazon’s Echo (or even Google Voice/Search). Rather than a cloud based intelligent system predicated on machine learning, Audio Autonomy requires a simpler logic that can be delegated to a caregiver who will make the complex curation and programming decisions.

4.0 Design paths not Taken

We had five initial project ideas. Fall detection was our first project idea, but it proved to be a huge “holy grail” problem of the field that may take decades for experts to solve. Another idea

was “elder cam,” an app to show how the world looks to an old person. For the purpose of making an environment safer for those who might fall, possibly via Augmented reality. That was too large a feat. Also too large was the idea of an “info portal,” with information and content for caregivers. It would capture existing best practices and advice that are fragmented. For patients, caregivers, and the public we had many training or simulation ideas of both games, and gamification, but they never crystallized into a narrow scope. We also considered mining public caregiver forum data, but had too little time, and that was a more of a method than idea. We chose Audio Autonomy because it aligned well with recent research about problems and solutions for dementia patient care, quality of life, and independent living.

Music has increasingly been used for many benefits of quality of life for dementia patients, improving mood, calm, and engagement. A nonprofit musicandmemory.org has seen successs implementing ipods with playlists in hundreds of nursing homes. As per research, singing and singing along with music can be helpful, so expression as well as listening can have benefits.

Design Factor	**Design Decision**
Voice options. Using a real person's voice could confuse the patient if they think someone is really speaking to them. Also, there is an "Uncanny Valley" - which is known to disturb or "creep out" even healthy people, when computer figures or voices fall ambiguously right in between seeming like computers vs. seeming like realistic renditions of people. This valley may exist for dementia patients differently, but this should also be avoided.	Any voice is possible, but by default and for advanced cases, use a definite computer-generated voice. Recorded Voices of loved ones, friends, voice actors, or caregivers, can also be used on a case-by-case bases.
Repetition of question usually happens in the exact same way.	Our ASR matching grammar can be very simple.
System cannot substitute for in-person, real, human social and emotional needs.	It is critical when testing or implementing to discuss the personal and social relationship dynamics. Any existing relationship tensions, conflicts, and strains could affect and be affected by new technology implementations. Also, repetitive questions

	can reflect anxieties (and not just memory loss), so audio responses may be addressing and identifying symptoms, not solving the actual problem.
Even though memory declines, patients retain the ability to learn many kinds of things, and be trained, especially in relatively simple motor tasks.	Take advantage of ability to learn and progress on these fronts. Don't try to fight the mental decline unrealistically in ways that can frustrate the patient or caregiver.
As memory declines, reminiscence activities "can create a sense of failure and lead them to shut down their communication." (timeslips.com)	Stories and personal memories can be appropriate content for audio. However, if they invite participation or pressure to remember beyond patient's abilities, it can be better to offer alternative experiences. For example, creative participation, such as singing along, or just expressing emotions in various ways. "They are allowed to be creators of something. They gain trust again in their ability to communicate, to make meaning." (timeslips.com)

5.0 Experts

5.1 Ben Shapiro

We spoke with Dr. Ben Shapiro, (a geriatric psychiatrist at the VA hospital in Los Angeles, and also Assistant Professor at UCLA), every two weeks (7 total times) to get feedback on our design ideas and decisions. He confirmed problems of patients and caregivers that we had seen in research papers, and added additional insights. He confirmed as per research papers that the buildup of annoyances (such as prevarication of the patient through repetitive questions) can contribute to caregiver burnout as much as the hard work itself.

Ben also explained that because dementia hampers an individual's cognitive functions, it is helpful to convey information, signals, or experience multimodally, or via several redundant channels. Audio Autonomy can be used to augment experiences already occurring in the patient's residence.

He also pointed out, in line with our research, that dementia patients regularly struggle with simple transitions during the day, such as getting up to eat breakfast. These moments often raise anxiety, agitation, and even anger. He explained that dementia sufferers have diminished initiative in some ways. Humans have normal tricks and mechanisms to get us over motivational hurdles for things we don't always want to do. Dementia patients often lose those mental and behavioral techniques. As a result, playing music or creating comforting structure to anticipate and facilitate transitions can help them and their caregivers.

He suggested adding comfort and structure to certain content by announcing “It’s 5pm. Your daughter has selected a classical music selection which I will now play for you.” Or, “It is 6pm. This is your computer assistant speaking, you can say ‘dance’ if you’d like to hear a dance song, or ‘no’ if you’d like to hear a gentle waterfall.” Announcing the time orients the patient that it may be time for a transition.

5.2 Micheal Pope

On March 18th, 2015 we had an informational interview with Micheal Pope from the Alzheimer's Services of the East Bay(ASEB). It was probably the single most important interview we conducted with an expert, and it fundamentally changed the way we understood our project space. Micheal started by telling us about ASEB, and the frankly amazing work they're doing caring for Alzheimer's patients.

Our most important take away from this meeting was the need for us to focus on the three fundamentals of Alzheimer's care; fraud, safety and activities of daily living (ADL). These three elements are fundamental to keeping dementia patients independent, and out of full-time managed care. Besides this key take away, Micheal also validated our decision to change our primary user group from the patient to the caregiver. This was an important early realization we had just made, and she validated the legitimacy of this decision.

She emphasized the importance of initiating early dialogue between caregivers and patients. Sometimes a tool's primary purpose is to act as a conversation starter between two family members who are grappling with the new found reality of Alzheimer's. Similar tools and games are used to introduce children to grapple with the death of their parents. Or to prepare

for situations in which a parent loses the ability to make decisions for themselves. In advanced stages, family can become desperate to have any connection or shared experience at all, and as per musicmemory.org, music can sometimes provide that sharing.

She pointed out the importance of routine in the daily life of Alzheimer's patients. This validated our idea of using a calendar to organize audio events for patients. She also made it clear that Alzheimer's patients can learn new behavior, and that it is important to provide positive and negative feedback as a way to shape behaviors for patients with Alzheimer's.

Finally, Micheal recognized the special connection between auditory stimulation and Alzheimer's that so many researchers are trying better to understand. We toured the ASEB center, where we saw numerous late stage Alzheimer's patients, and there was a constant stream of music. She recognized that certain music created a calming mood, and a lack of music increased distress in the patients. The intersection of music and Alzheimer's is so incredibly intriguing, while at the same time not very well understood, that one can only assume that groundbreaking research in this area will soon be forthcoming.

6.0 Technical Specifications

The software component of Audio Autonomy comes in two parts; an audio interface, and a web interface. The web interface is used by caregivers, while the audio interface is what patients use. Tying both together is their mutual dependence on a single MySQL database. The web interface both reads and writes to the database, while the audio interface only reads the database. See Appendix A for a general technical overview of our entire system.

The source code for Audio Autonomy is hosted on Github.

https://github.com/smutt/groundhog

6.1 Events

The concept of an event is important for Audio Autonomy. Caregivers configure audio events for patients with the web interface. There are two kinds of events that can be scheduled by caregivers, all-day events and time-triggered events. All-day events are active for an entire day, and triggered by a patient's voice. The only all-day event type we currently support is 'Question and Response' events. Via the web interface a caregiver enters both the question text, and the response text. At any time during the day, when their patient says the question text, the audio interface will then repeat the answer text. For example, a caregiver might enter the question "What time is dinner?", and the response "Dinner is at 6pm."

Time-triggered events fire at the time specified by the caregiver. There are many examples of time-triggered events. Currently we support five different reminders, playing of a patient's favorite song, and activating a fraud prevention exercise. Time triggered events can only be scheduled on the half-hour, and typically last for no longer than two minutes.

6.2 Web Interface

The web interface is for the caregiver to schedule events for their patient. After logging into the web interface a caregiver is redirected to our scheduling application , which resembles a grid-based calendar. There are currently two very different types of events: scheduled events that occur at a specified time, and “listener” events that monitor for vocal prompts, and then activate voice interaction or content. Each of these two event types can have many subtypes,

such as medication reminders, music playlists, or specific prompt-responses, which can in turn have specific instances throughout the calendar.

To instantiate an event in the calendar, Caregivers drag these events from the left-side menu of possible events, onto the calendar on the right. They can drag as many of each event type they want, and can place multiple events in the same calendar time slots. As per calendar conventions, there is an “all-day” area at the top for all-day events, and since “listener” events are currently monitoring all day, they always go in this top area.

Caregivers can move existing events around within the calendar, but the interface prevents users from dropping time-triggered events into the all-day grid for each day, and also prevents the all-day listeners from being dragged into the time-slots part of the grid. If all-day events are dropped onto a specific time they appear in the all-day grid section at the top of the day. Clicking on an event instance within the calendar show a modal window with basic event information, with a button to delete the event. Any event can also be deleted by dropping it onto a trash can icon or the “origin” menu on the left.

When an all-day listener event is dropped to the calendar, the caregiver can type the question or command that the patient will ask, and also the answer the system will give to the patient. Since the calendar database is polled every half-hour (or even more frequently), as soon as the event appears in the calendar, it is instantiated, and the system has been programmed to make the event happen at the right moment.

Both day and week views are available, and caregivers can advance or reverse the time frame by day or week increments. The current day is always highlighted on the calendar, and a button takes the viewer to the current day.

More menu items can easily be added to the system with some simple html code, and menu items for more more complex interactions or “mini” programs could be added with some additional php and xml code. We have showed relatively simple examples for illustration. We also locked down, removed, or avoided many optional calendar features, in order to create an extremely simple interface with virtually no onboarding or learning time, and to focus on only the most important caregiver decisions as we currently understand them.

We implemented a crude insecure login access system, but such a system could easily be properly hardened or even integrated with a content management system, utilizing the login/access features and the platform’s language and database.

6.3 Audio Interface

The audio interface is for the patient to interact with scheduled events, and other audio features. It's understood that a caregiver would probably do an initial logging in and password speaking. Upon dialing in the patient’s calling number, or Automatic Number Identification(ANI), is used similarly to a username for identification. ANI is the Q.931 Integrated Services Digital Network(ISDN) term, along with DNIS and RDNIS, which references the calling party identifier. They are then asked to say their password, which must be an english dictionary word. Complete Call flows for the demo audio menu are shown in Appendix B and C.

6.3.1 Audio Identifiers

The audio interface is agnostic to transport layer, working over Skype, SIP or traditional PSTN telephones. A SIP end-point looks like an email address prefixed with the SIP protocol identifier(e.g. sip:user@example.com). A Skype end-point is the case insensitive Skype username(e.g. skypeuser1). A PSTN phone number is the E.164 number without the prepended plus sign and country code(e.g. 5109009524). Due to limitations in Voxeo's free hosting our application is limited to American and Canadian PSTN end-points. Voxeo's VoiceXML interpreter determines which transport layer to use based on the format of the end-point identifier. For the purposes of our application, identifiers representing audio end-points are referred to as phone numbers.

6.3.2 VoiceXML

VoiceXML is a W3C standard, and there are numerous VoiceXML providers. VoiceXML was developed to allow call centers to more easily program telephony user interfaces(TUIs) using a paradigm of programming that was successful for the web. A VoiceXML browser can be seen as a translator between audio and VoiceXML text files. This is similar to viewing a web browser as a translator between HTML and visual elements displayed on a screen.

VoiceXML is an analogue to HTML, and a VoiceXML browser is an analogue to a web browser. The VoiceXML standard specifies that browsers support ECMAScript, Javascript is the most common ECMAScript compatible language, and the most widely supported on VoiceXML browsers. ECMAScript was developed and standardized by the European Computer Manufacturers Association(ECMA). In much the same way the Document Object

Model(DOM) is available for manipulation in HTML browsers, so is the DOM available for manipulation in VoiceXML browsers. In addition the VoiceXML specification requires browsers to support specific stateful variables for ECMAScript manipulation. For example, we use 'session.callerid' to capture the ANI of the calling party and identify the calling patient. A patient's ANI is our analogue to a patient's username.

The server side programming paradigm of VoiceXML is also borrowed from the web world. An HTTP server can serve static VoiceXML documents in much the same way an HTTP server serves HTML documents. Or an HTTP server can use a server side scripting language to generate VoiceXML documents. Voxeo's VoiceXML browser also supports HTTP cookies, which we use for session management.

By mimicking the successful programming paradigm of the web, VoiceXML benefits from all the tools that have developed around server side web development. The server side architecture of our audio interface is basically Linux, Apache, MySQL and PHP(LAMP). Instead of outputting HTML we output VoiceXML. This makes it quite easy to build complex and dynamic logic for the patient’s audio experience and navigation.

6.3.3 Voxeo's Role

We chose Voxeo because it was the easiest to get up and running quickly, they also have a very useful online debugger for applications. Voxeo supports, and we use version VoiceXML 2.0. Voxeo maintains a mapping of a phone number to URI. When this phone number is dialed Voxeo's VoiceXML browser fetches the corresponding URI via HTTP and begins parsing it. This is the only configuration done on Voxeo.

6.3.4 Limitations of VoiceXML and Voxeo

VoiceXML was designed for commercial interactive voice response(IVR) systems. Most people interact with VoiceXML when they're interacting with a call center, or navigating a voice-mail system. It was not designed to be used in a passive environment with considerable background noise. This means background noise can ruin attempts at distinguishing spoken words. This can be partly overcome with better hardware, but not entirely.

VoiceXML also requires static ASR grammars to be specified at page-load-time. I don't think Amazon's Echo works like this. Instead I suspect the Echo hardware recognizes when speech audio begins and ends, then packages the speech chunk to be processed on Amazon's CPUs using recursive grammars. VoiceXML does not support recursive ASR grammars. This means the types of ASR grammars we can specify are much more limited than what I observe the Echo to be capable of.

Voxeo also limits certain functionality on outbound calling due to abuse. They don't want their platform to be used for robo-calls. Ironically, this is why we cannot dial a patient's landline to initiate the fraud exercise. Voxeo prohibits this because it's how fraudsters would abuse their system. We use Skype and SIP client Jitsi instead of a landline, for demo purposes.

6.4 Database

The database is a basic MySQL database with three tables. Table 'caregivers' holds login data for caregivers, and links to their associated patient. Table 'patients' holds login data for patients, including their calling phone number, help phone number and fraud phone number.

Both tables hold volatile session data mirrored in cookies set on both the VoiceXML browser and web browser. Caregivers login to the web interface and schedule events for their associated patient. Table 'events' holds this event data. The ‘events’ table also holds CSS class information about the events to help the calendar maintain proper visual styling while synchronizing the user interface with the database.

6.5 Security and Privacy Considerations

When developing we noted security issues, and we intentionally developed in a way that would allow us to return to our product, note problems, and fix them. There are no deal-breaking security gotchas with our project. In short, we tried to be conscious of the technical debt we were incurring. This section will note where security needs to be improved in the project prior to any general purpose release.

Every instance of HTTP connections needs to be replaced with HTTPS. This goes for both the server to VoiceXML browser, and server to web browser. We need to store all password information as an encrypted hash with a different salt per-user. Currently we store both the web and voice passwords as unencrypted strings. We are also susceptible to MySQL injection attacks, so we need to properly filter all incoming and outgoing data, as well as dynamically generate security tokens for our modal form submissions. Our cookie/session handling should be reviewed to determine if there are cross-site scripting vulnerabilities. If an attacker builds their own VoiceXML browser and engages in ANI spoofing they could probably login as an arbitrary patient, or capture a patient's password. AJAX calls from web browsers to our server are unencrypted, and unauthenticated.

Security is generally understood as a dependency of privacy, no system can adequately ensure privacy if it is insecure. This section enumerates privacy concerns assuming a perfectly secure system.

Audio Autonomy generates and stores individually identifiable protected health information(PHI) as defined by Health Insurance Portability and Accountability Act(HIPAA). The log files are not de-identified from the patients or caregivers, and the database stores information on all patients and caregivers unencrypted. Specifically Audio Autonomy stores phone numbers, names, dates and IP addresses. In addition, voice recordings of patients might be considered biometric identifiers and qualify as PHI.

Any roll-out of Audio Autonomy to real patients would require a complete review of its data use and retention. It would also require the generation of a privacy and data retention policy. Both of which would be a significant undertaking.

7.0 Literature Review

We performed a study of the literature on Alzheimer's Disease(AD) and audio stimuli prior to writing any code. The benefits of music for dementia have been documented by musicandmemory.org "Music and Memory: Making the Case for Personalized Care" (p. 5 - 6). Some examples:

- Finally, professional staff have a way to give pleasure to persons with advanced dementia--often the most difficult to reach. Personalized music provides a means of communication and self expression when verbal language abilities are diminished.

- Musical favorites replace confusing environmental stimuli with something interpretable; personalized playlists distract from boredom or distress with a soothing, familiar experience.
- Individual are more cooperative, attentive, and willing to accept care; musical favorites decrease agitation and provide a distraction from fear and anxiety.
- Because individuals are calmer and less agitated, sundowning is often reduced or eliminated. The music decreased wandering during mealtimes and restlessness.
- Individuals are more engaged with those around them.
- Family and staff are able to connect in a more meaningful way with residents around music and memories

Musical memory is special, but how special is it? Our study uncovered two main conclusions. First, musicians have increased plasticity in later life, and are less susceptible to dementia. The ability to play music might even be unforgettable once we have learned an instrument to a certain degree. Second, music, especially melodies, are one of the most successful methods for evoking reminiscence moments, communicative expressions, and emotional responses, in later term dementia patients. This is a very active area of research, and a very difficult subject to research. We should expect future research to uncover more amazing discoveries.

Other interesting papers are listed below with a brief summary of each of their findings. Sentences in quotes come directly from the papers themselves.

"[T]he powerful and long-lasting memory-enhancing effect for musical stimuli raises the potential benefits of using music stimuli in rehabilitation of brain-damaged patients. By eliciting emotional experience, musical listening conveys a conceptual representation that seems to remain accessible in these patients."

S´everine Samson, Delphine Dellacherie, and Herv´e Platelc.

Emotional Power of Music in Patients with Memory Disorders.

Ann. N.Y. Acad. Sci. 1169: 245–255 (2009).

doi: 10.1111/j.1749-6632.2009.04555.x c 2009 New York Academy of Sciences.

"There is evidence that music may be one form of communication that remains preserved in persons with AD." Also, patients exposed to musical therapy generated more verbal and nonverbal expressions than the control.

Mary Sambandham, Victoria Schirm,

Music as a nursing intervention for residents with Alzheimer's Disease in long-term care,

Geriatric Nursing, Volume 16, Issue 2, March–April 1995, Pages 79-83, ISSN 0197-4572,

"Implicit, specifically procedural musical memory, or the ability to play a musical instrument, can be spared in musicians with AD. In contrast, explicit musical memory, or the recognition of familiar or unfamiliar melodies, is typically impaired. Thus, the notion that music is

unforgettable in AD is not wholly supported. Rather, it appears that the ability to play a musical instrument may be unforgettable in some musicians with AD."

Amee Baird & Séverine Samson

Memory for Music in Alzheimer's Disease: Unforgettable?

Neuropsychol Rev (2009) 19:85–101

DOI 10.1007/s11065-009-9085-2. Published online: 13 February 2009

"Patients with AD demonstrated better recognition accuracy for the sung lyrics than the spoken lyrics, while healthy older adults showed no significant difference between the two conditions. We propose two possible explanations for these findings: first, that the brain areas subserving music processing may be preferentially spared by AD, allowing a more holistic encoding that facilitates recognition, and second, that music heightens arousal in patients with AD, allowing better attention and improved memory."

Nicholas R. Simmons-Stern, Andrew E. Budson, Brandon A. Ally,

Music as a memory enhancer in patients with Alzheimer's disease

Neuropsychologia, Volume 48, Issue 10, August 2010, Pages 3164-3167, ISSN 0028-3932,

8.0 Future Considerations

This section will list some of the features or aspects of Audio Autonomy that we would like to see in future versions. As for the features we implemented, the main driver for any future

features are our experts. Who not only have been critical in shaping the product thus far, but have identified its shortcomings and functionality gaps.

Due to time and ethical concerns we were not able to test with our actual user groups. This has limited our feedback to experts, and while the experts have been great, there is no real substitute to user interface testing with actual users. The most critical user experiences would be the patients' audio interface, which should drive the design, since meeting their needs is the primary evaluation priority. As features of the audio interface prove viable and beneficial, the interface design for the caregiver tool would follow. Since the web interface is relatively lightweight, at that point fine-tuning that management layer would follow in turn, and extensive interface testing with caregivers would improve their experience. Though some parallel research and testing could happen, the audio interface is primary; the web management interface is secondary.

Ben Shapiro and David Lindeman of Citris encouraged us that innovation can happen by rapid implementation of prototype ideas. Since proper clinical or ethical user research must follow protocols, alternative experiments can allow for rapid learning. The also stated that academic research is both valuable and necessary, but very slow in its rigor and methods, so iterative agile methods primarily developed in the commercial sector and hacker communities can drive many ideas and reveal opportunities.

Ben Shapiro thought Audio Autonomy should take a more 'computer assistant' approach to interacting with patients. He wanted the product to explicitly identify itself, and use more explanatory language to engage the patient. For reassurance, it could say “I am your Audio

Assistant. I am on and listening." He would like the product to regularly say things to engage the patient, maybe state the time every hour, or engage in reminiscence exercises or games. He talked about the importance of orientating dementia patients with regular, repetitive audio prompts. He would also like to add more functionality that strengthens the relationship between caregiver and patient.

There are many simple features we would like to add. For example, the ability in the caregiver interface to add recurring events. We briefly toyed with this idea in our interface before realizing it was much more difficult than we had first imagined. The definition of 'recurring' is not clear, and we would have needed to create a more complicated interface for the caregiver. We even found an entire paper by Martin Fowler about the design of recurring events for calendars. Voice functionality would also strengthen the web interface. Instead of requiring the caregiver to type in questions and their responses, they could type in a question and then record a response.

We need to make it as easy as possible for caregivers to maintain a routine for their patient. We could add templates of suggested routines. They could start with a template, and then modify it fit their patient's more specific needs. We could add a setup Wizard for the caregiver that introduces them to the functionality, and makes good default choices for them.

9.0 Conclusion

The spaces of ambient assisted living, Amazon's Echo, Apple's Siri, and IoT are wide open, with clouds, sensors, and devices all experimenting with various open and closed, proprietary, and hybrid integrated approaches. With variations of automation, intelligence, content, and interaction, they are tackling personalization and context-aware features that even for healthy people are extremely challenging. The needs of dementia from these systems are not well-known, but dementia patients will have specific needs for the full range of quality of life and clinical support, to sustain independent living.

Our audio features could become part of a mobile virtual companion robot, which possibly speaks to internet services and home networks. Our goal was to cluster a set of features that could be implemented together, into a promising, relatively simple set of well-known audio solutions for dementia that have not yet had technological integration and simple management.

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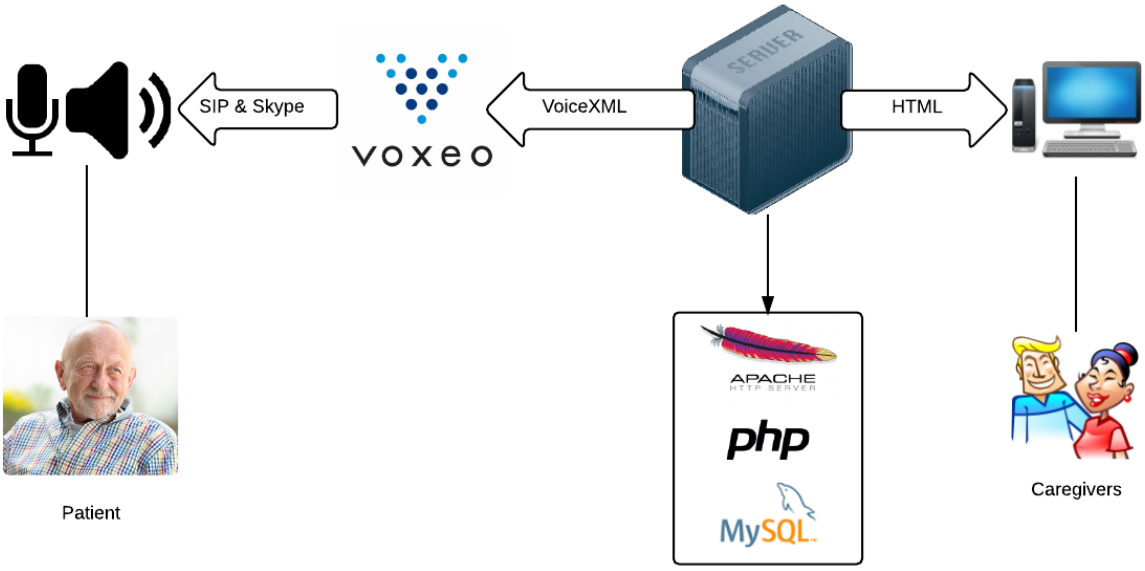
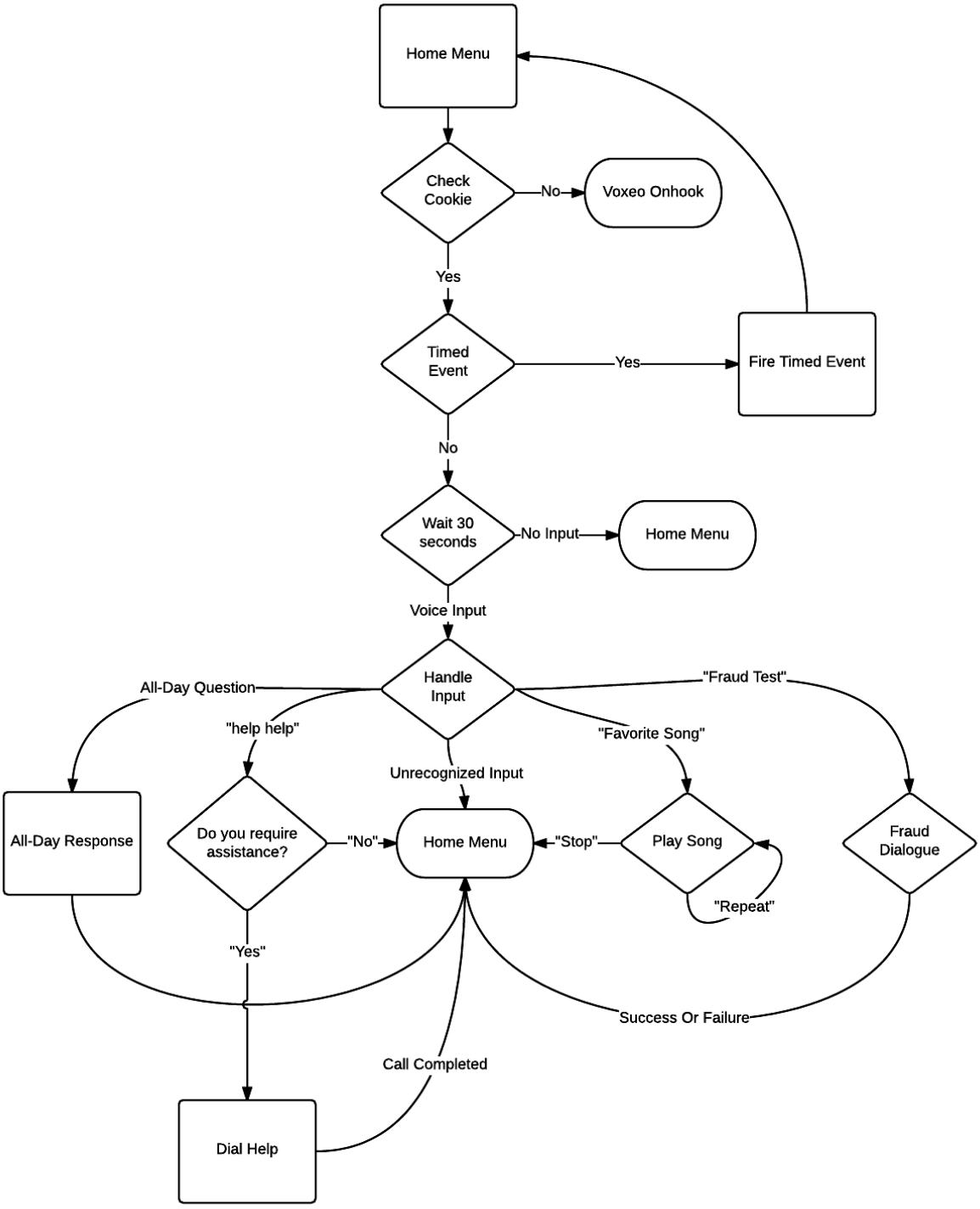
Appendix A


SIP & Skype
voxeo
VoiceXML
SERVER
HTML
Patient
APACHE
HTTP SERVER
php
MySQL
Caregivers

Appendix B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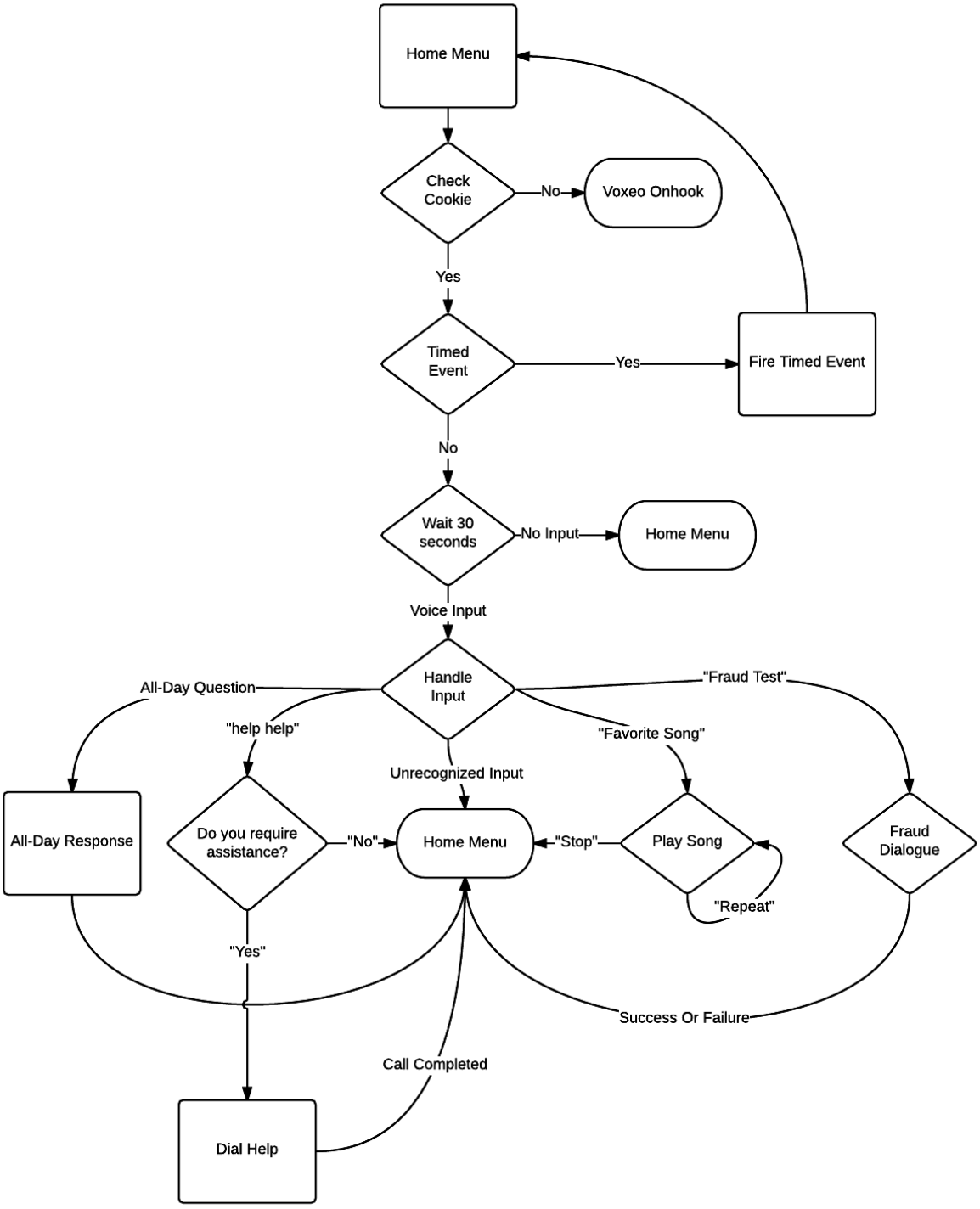
Check Cookie
No
Voxeo Onhook
Yes
Timed Event
Yes
Fire Timed Event
No
Wait 30 seconds
No Input
Home Menu
Voice Input
Handle Input
All-Day Question
"help help"
Unrecognized Input
"Favorite Song"
"Fraud Test"
All-Day Response
Do you require assistance?
"No"
Home Menu
"Stop"
Play Song
"Repeat"
Fraud Dialogue
"Yes"
Success Or Failure
Call Completed
Dial Help

Appendix C


Home Menu
Check Cookie
No
Voxeo Onhook
Yes
Timed Event
Yes
Fire Timed Event
No
Wait 30 seconds
No Input
Home Menu
Voice Input
Handle Input
All-Day Question
"help help"
Unrecognized Input
"Favorite Song"
"Fraud Test"
All-Day Response
Do you require assistance?
"No"
Home Menu
"Stop"
Play Song
"Repeat"
Fraud Dialogue
"Yes"
Success Or Failure
Call Completed
Dial Help