# Platform Based Design Process of a Standard Commercial Product: Answering Machine System


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**ENPM 643**
**Fall 2004**

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## 1. Abstract

The demand for new commercial products is increasing at an accelerated pace. The communication revolution has allow for the development of a global market economy in which competing industries strive to satisfy the diverse needs of billions of individuals in order to survive. But with the daily innovations and technology advances, each with different infrastructure requirements, configuration management and interoperability of products and systems is far from ideal. Add to this the constant pressures and demands from corporate management to shorten product development times, while reducing total production cost and we move closer into the chaotic arena.

With the years, these new-age challenges have produced the appropriate stage for Systems Engineering methodologies to be recognized and adopted by all private and public institutions. Although the inception of System Engineering can be traced back to the Cold War era when the Department of Defense imposed the first quality standard on special programs like the Polaris (later Poseidon and currently Trident), the full suite of SE methodologies has been misunderstood and underappreciated by the private industry sector for decades. However, current challenges confronting manufacturing enterprises have forced the larger corporations to adopt pieces of SE methodologies under different names (i.e. Six Sigma, Life Cycle Management, Total Quality Management, and among others).

In this paper we have chosen to propose a framework based on SE methodologies learned in ENPM 641, 642 and 643 that allows the design of a family of answering machines. We have chosen to expand the SE paper that we generated during the ENPM642 class of Spring 2002 and introduce new SE elements that allow for better identification of platform requirements, improve traceability, validation and verification.

## Introduction

This document offers guidance for the optimal development of platform-based design of a commercial product by defining a repeatable process of development. We have focused on the identification, traceability and V&V of architectural driver requirements, which are common to all the product variants.

One of the industry drivers of this movement is the need to facilitate development of future product generations that are extensions of original hardware and software investments, thus allowing for reduced time to market, while decreasing development and production costs. Another driver is the need to control the ever-increasing cost attached to the verification and testing of each new component introduced in an already complex system. Component communality leads to process communality advantages in areas like testing, validation and verification.

There can be re-use at the different levels of abstraction. However, the benefits of re-use will be the most beneficial at lower levels of abstractions. In the case of our project, we

have focused much effort in re-using components in the distinct products, so that we can obtain and verify the benefits of the "re-use" concept.

## 2. Overview of Process to Design a Family of Products

The following process defines a development path for generating a family of products:

1) Select the Design Team: All systems and products are the effort of a group of individuals with different specialties (i.e. structural engineers, software developers, electrical engineers, marketers, etc). The start of the product development phase begins with the selection of the design team.

2) Goals and Scenarios: The design team determines the goal of the family of products by analyzing and interpreting market data. In this case our goal is to design a family of answering machines. The goal can start with a generalization, but the subsequent definition of Use-Cases Scenarios help gather more specific information about the customer needs.

3) High Level Requirements: These requirements are derived from the Use-Case Scenarios and specify the "what" of the system without compromising the architectural design.

4) Define Architectural Drivers: These are requirements that are common to all members of the product family. Generally all high level requirements are architectural drivers of the family of products. Lower level requirements are less inclined to drive the design of the platform, but they are essential to customizing the child products later on.

5) Refine Requirements: Define lower level requirements.

6) Group Requirements and Assign Importance: Group requirements per functionality and assign the level of importance to either the family platform (architectural driver) or a specific need of a market segment.

7) Model System Structure: The synthesis of requirements and architectural drivers allow the development of the system structure.

8) Model System Behavior: Requirement synthesis and analysis also serve as the basis for deriving the overall system behavior.

9) Define System Design: The mapping of the systems behavior onto different alternatives of the system structure permits the design team to come up with various design alternatives. Subsequent, alternative ranking and optimization help eliminate inferior solutions.

10) Identify High-Volume Components: Economy of scales is one of the advantages of designing a family of products, since reducing cost of production while retaining quality is one of the main goals of every product development team. Consequently, the early determination of the components providing the shared functionality among family members gives designers an edge to plan for large scale production, acquisition, and reuse. What is attractive of the design of a product family is the optimization of manufacturing line resources. A phased approach to manufacturing allows for different components to be manufactured using the same production line. Of course a phased approach requires a comprehensive project management effort, since some decisions that will drive the platform architecture will be made earlier than in the conventional approach.

11) System evaluation: The preparation of the verification plan is essential to determine that all system requirements are being satisfied by the system attributes by the different design options. Through validation we check for requirements to have addressed the stakeholders' needs throughout the development process. The purpose of the verification process is to assert compliance with specified requirements.

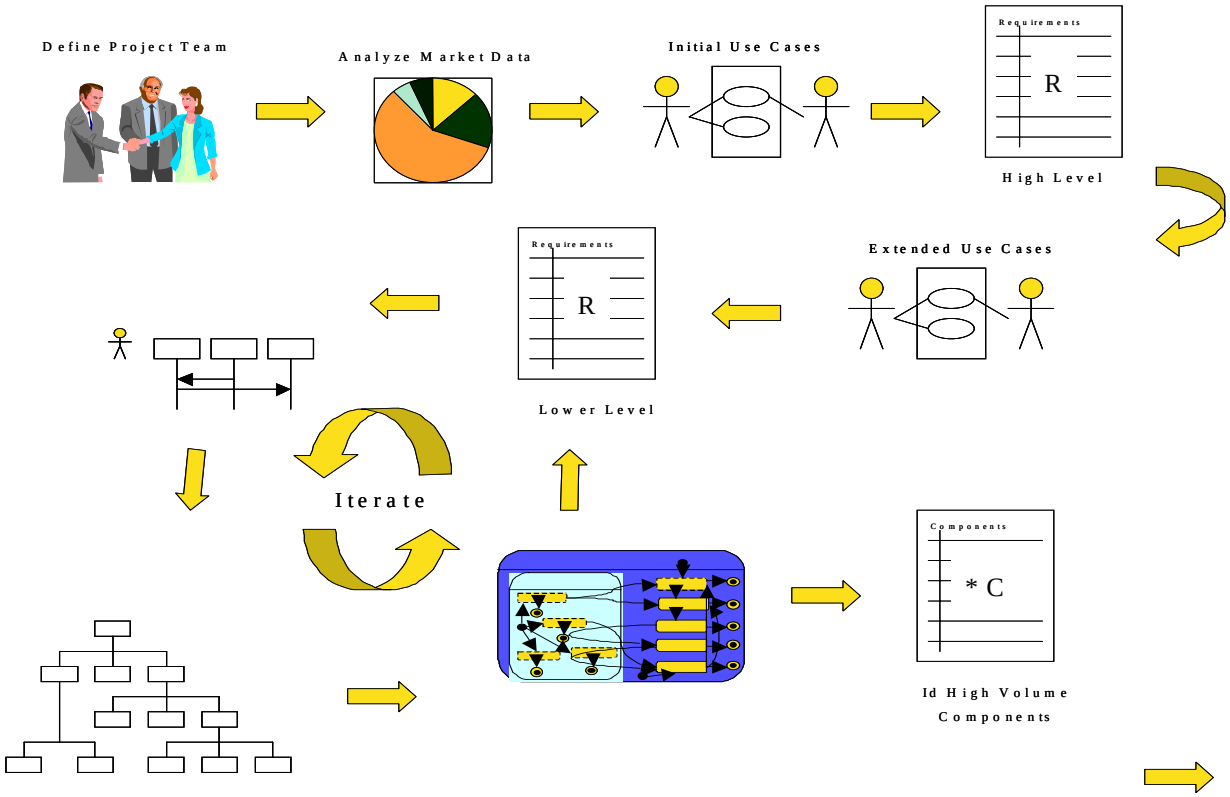
12) Iterate: The design process is an iterative process, so be ready to revisit previous steps until all use cases, requirements and system models reflect the stakeholders' needs. Of course design team compromises, based on trade studies and trade-off analyses, will have to be made along the way.

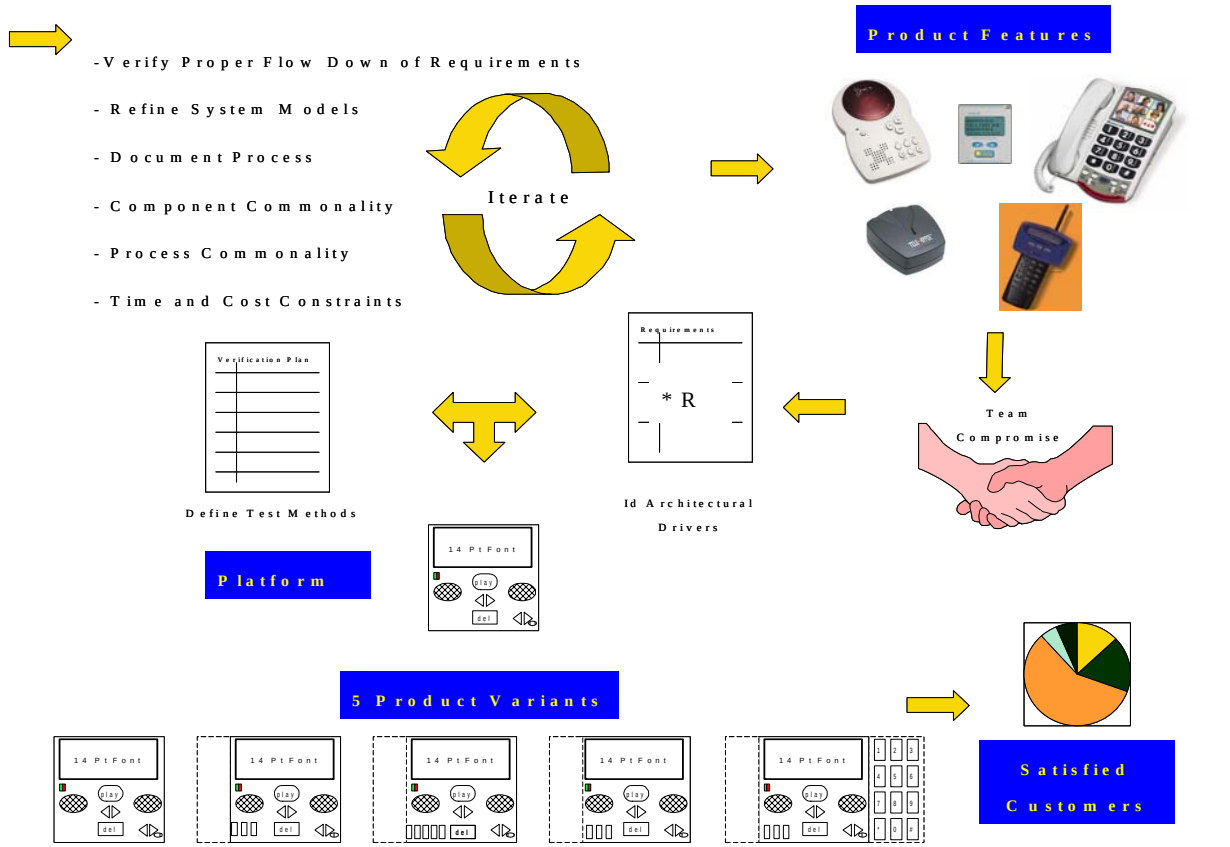
13) Production: The family of products is manufactured and/or undergoes final assembly.

14) Validation and Verification: At this point it becomes very costly to correct faults or errors, but it is essential to check that we have produced the intended product and that all requirements have been captured. To minimize costs some type of V&V shall be performed before every major decision points (ie, System Requirement Review, Conceptual Design Review, etc). End-user manuals are finalized after production and hazards are identified for study of potential product recalls. Product recalls are damaging not only for the direct cost associated with them, but they detrimental for the company reputation.

15) Market entry: Family of products enters the market.

Figure 1 below shows a flow diagram of the design process for a family of products.


Define Project Team
Analyze Market Data
Initial Use Cases
Requirements
R
High Level
Extended Use Cases
Requirements
R
Lower Level
Iterate
Components
* C
Id High Volume Components
Cont'


-Verify Proper Flow Down of Requirements
- Refine System Models
- Document Process
- Component Commonality
- Process Commonality
- Time and Cost Constraints
Iterate
Product Features
Requirements
* R
Id Architectural Drivers
Team Compromise
Verification Plan
Define Test Methods
Platform
14 Pt Font
5 Product Variants
Satisfied Customers
End

## 3. Goals, Scenarios, and Use Cases

This section provides various scenarios developed from the high-level requirements which will be represented through use cases and expanded by activity diagrams.

Goal 1: The system must be secure.

- Scenario 1.1 – Message recordings shall be accurate and not alterable.
- Scenario 1.2 – Messages shall be secure.

Goal 2: The system must be efficient.

- Scenario 2.1 – The system shall record a large amount of voice recordings.
- Scenario 2.2 – Announcement recordings shall be changed and rerecorded with ease.
- Scenario 2.3 – Message playback should occur quickly.

Goal 3: The system must be economical.

- Scenario 3.1 – The cost of the system should be affordable.
- Scenario 3.2 – The operational cost should be negligible.

Goal 4: The system must be usable.

- Scenario 4.1 – The system shall be easy to use with only the manual as a resource.
- Scenario 4.2 – The user shall easily understand the display.
- Scenario 4.3 – The input devices shall be intuitive to the user.
- Scenario 4.4 – Prompts shall provide the user clear guidance to required inputs.
- Scenario 4.5 – The messages should be accessible from a remote site.
- Scenario 4.6 – The system shall be compatible with all phones.

Goal 5: The system must be reliable.

- Scenario 5.1 – The system should remain working in a power outage.
- Scenario 5.2 – Changes to setting adjustments shall be incorporated into performance.

Goal 6: The system must be easy to maintain.

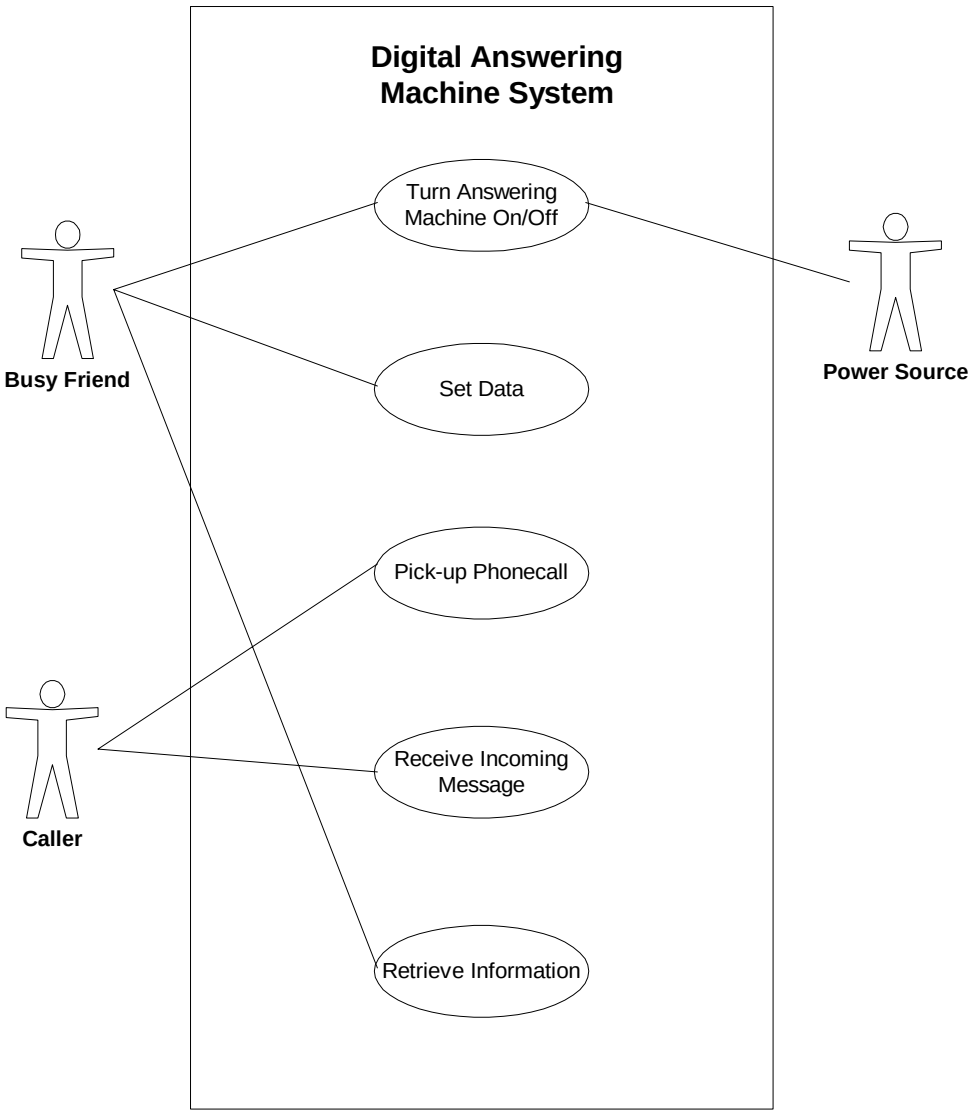
- Scenario 6.1 – The system’s battery compartment shall be easily accessible.

Goal 7: The system must be easy to store.

- Scenario 7.1 – The system sits on a horizontal surface.
- Scenario 7.2 – The system is attached vertically to the wall.

**Use Case Analysis**

**Initial Use Case**




**Primary System Actors** – These system actors represent the platform design of the Answering Machine System.

- **Busy Friend**: Person not answering phone call, and therefore, receiving message on answering machine. Also, person adjusting settings on answering machine.
- **Caller**: Person calling Busy Friend's phone line and leaving an incoming message for Busy Friend.
- **Power Supply**: External device (either AC/DC adapter or batteries) supplying answering machine with power.

**Secondary System Actors** – These system actors represent the added features of the various answering machine product lines. They are shown in extended use cases.

- **Roommate**: Person in close proximity to Busy Friend's answering machine, making Roommate able to leave Busy Friend a memo by directly interfacing with answering machine.
- **Incoming Message**: Recording stored in answering machine as a result of either Caller's phone call or Roommate's memo.
- **Telemarketer**: Person calling Busy Friend's phone line from computer generated phone call.

**System Boundary**

The Answering Machine System is considered the actual electronic device that records and stores messages and returns the messages when prompted. The Power Supply that supplies the power and the actual Incoming Message(s) recorded and stored are both considered external to the system.

**Use Case 1: Turn Answering Machine On or Off**
Primary Actors: Power Source, Busy Friend
Description: Busy Friend turns the Answering Machine On (or Off).
Preconditions: The Answering Machine is turned off (or on).
Flow of Events: The Busy Friend presses a button to turn the answering Machine on (or off).

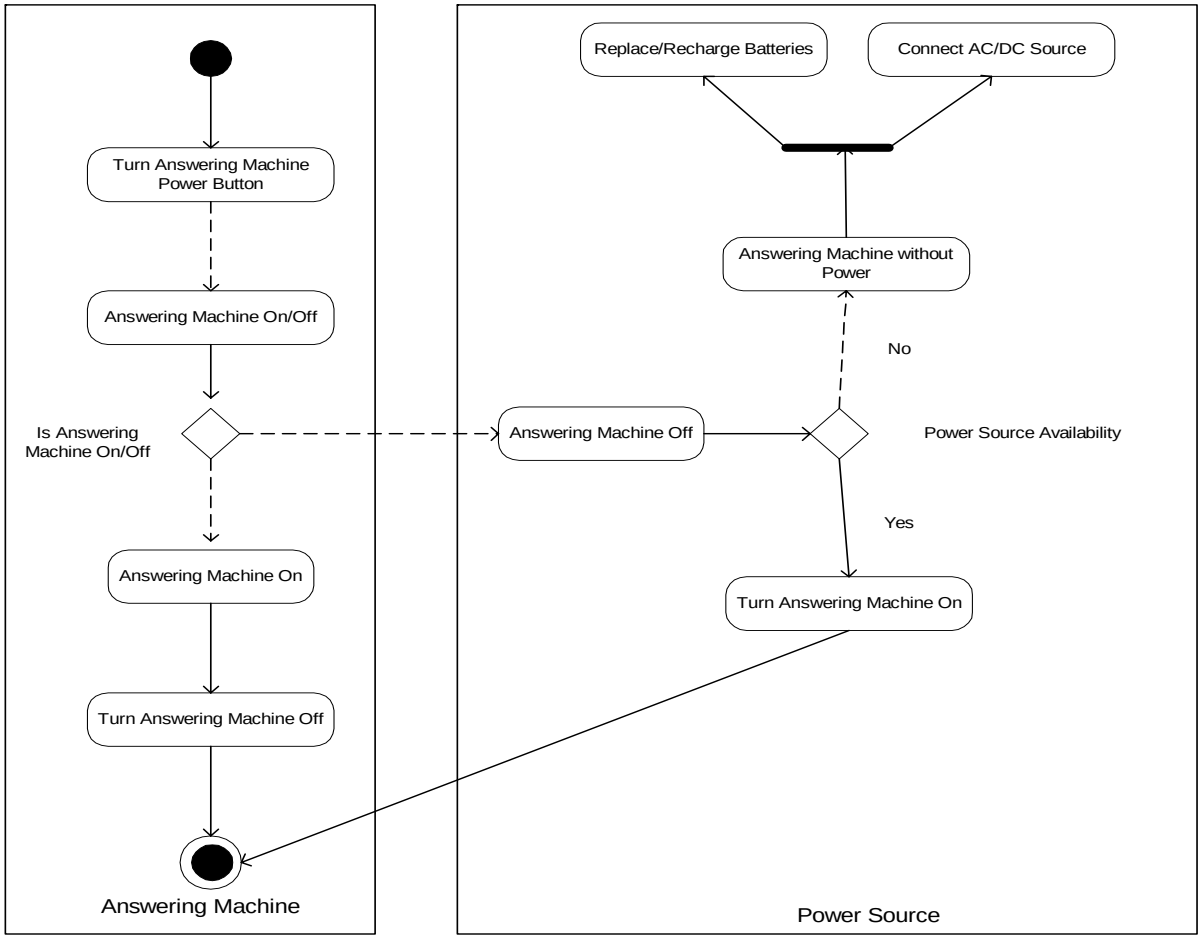
1. If the Answering Machine is off, pressing the button will turn in on.
2. If the Answering Machine is on, pressing the button will turn it off.

Post conditions: The Answering Machine is turned on (or off).
Alternative Flow of Events: An adequate Answering Machine power source may be unavailable.

1. Connect Answering Machine to the AC/DC power source.
2. Make sure batteries are either replaced or recharged.

Assumptions: Batteries and AC/DC power sources are available.

**Activity Diagram:**




**Use Case 2: Set Data**

Primary Actors: Busy Friend

Description: Busy friend set data such as outgoing message and settings in answering machine

Preconditions: Answering Machine is turned on and has adequate power source.

Flow of Events: To set data

1. Press control button to desired data option (outgoing message, settings)
2. Record or set appropriate data
3. Save settings
4. Exit settings function

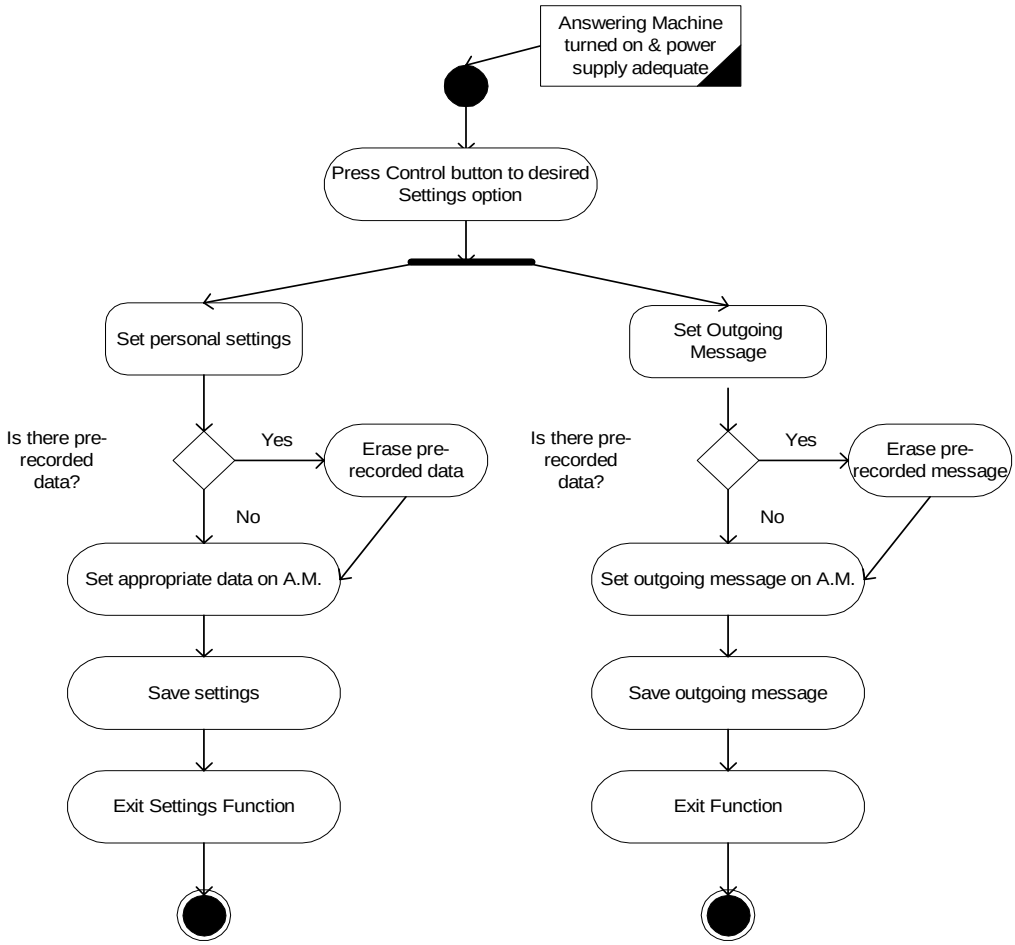
Post conditions: Personal data for answering machine have been set.

Alternate Flow of Events: Already has previously recorded data.

1. Press control button to desired data option.
2. Erase pre-recorded data
3. Record new data
4. Save settings
5. Exit settings function

Assumptions: None

**Activity Diagram:**




**Use Case 3: Pick-up phone call**

Primary Actors: Caller

Description: Busy Friend is unavailable during the call; the Answering Machine picks up the call.

Preconditions: The number of rings from the telephone has been set before Answering Machine picks up unanswered call. Answering Machine is turned on and has adequate power source.

Flow of Events: After set number of rings is achieved, the Answering Machine picks up the call.

1. The phone rings pre-determined number of rings.
2. The Answering Machine connects to the caller's phone call.
3. The Answering Machine plays outgoing message.

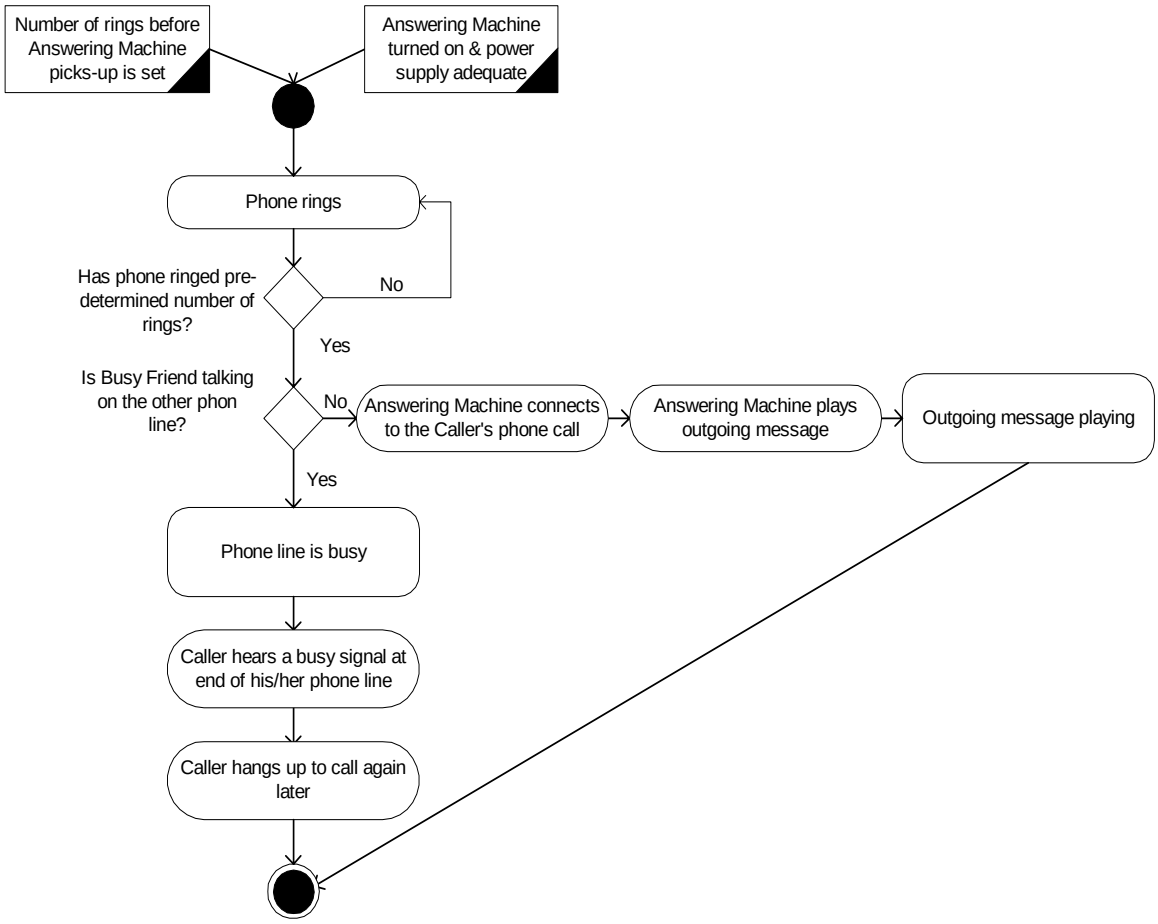
Post conditions: The caller hears outgoing message from Answering Machine.

Alternative Flow of Events: Busy Friend is on the other line

1. The caller hears a busy signal at the end of his/her line
2. The caller hangs up and waits to call later.

Assumptions: Busy Friend is unavailable.

**Activity Diagram:**




**Use Case 4: Receive Incoming Message**

Primary Actors: Caller

Description: Answering Machine picks up call of Caller and records/displays incoming message and data stamp.

Precondition: The Answering Machine recording capacity is not full. Answering Machine is turned on and has adequate power source.

Flow of Events: Answering machine receives incoming message

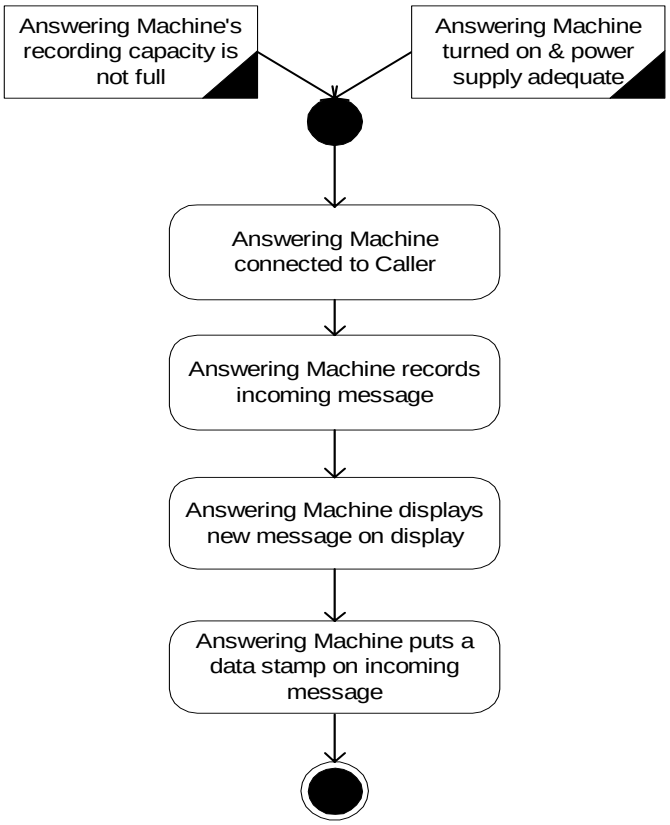
1. Answering machine records incoming message from caller.
2. Answering machine displays new incoming message in display.
3. Answering machine puts a data stamp on new incoming message.

Post conditions: Incoming message has been recorded.

Alternative Flow of Events: None

Assumptions: Busy Friend unavailable

**Activity Diagram:**

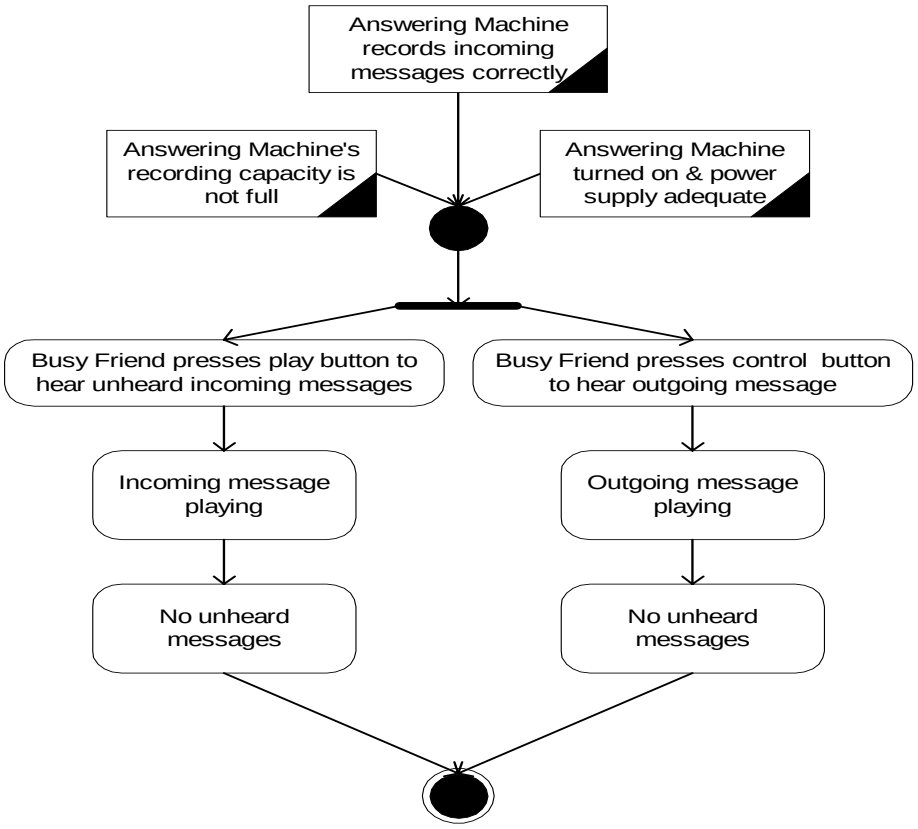



**Use Case 5: Retrieve Information**
Primary Actors: Busy Friend
Description: Busy Friend retrieves all information (outgoing/incoming messages).
Preconditions: Answering Machine records incoming message properly. There was adequate recording space in answering machine. Answering Machine is turned on and has adequate power source.
Flow of Events: Busy Friend retrieves various information in answering machine.

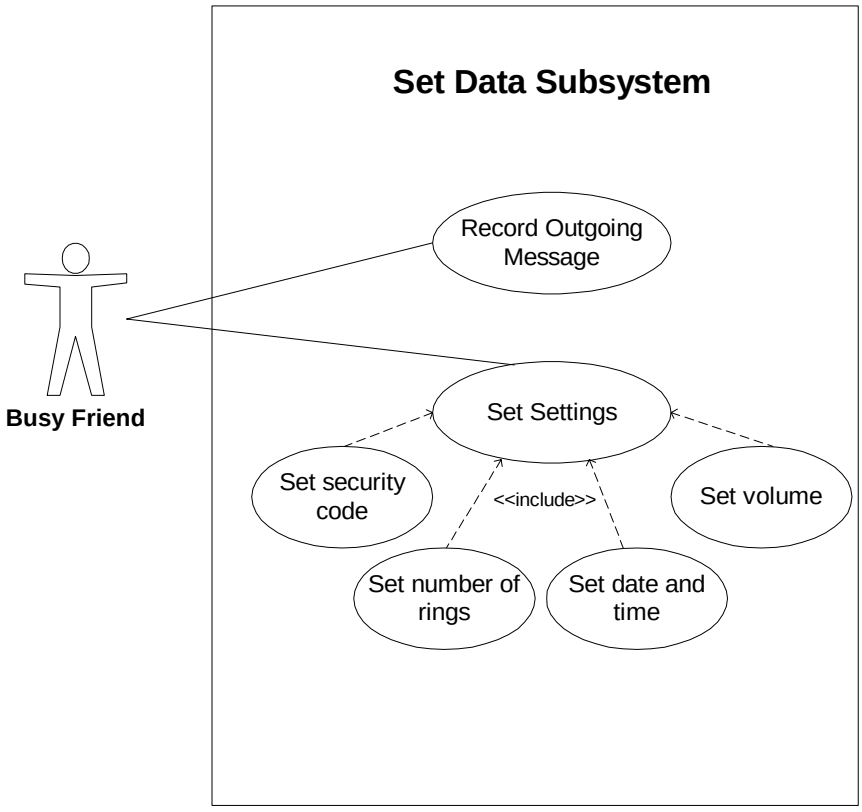
1. Busy friend plays back incoming messages.
2. Busy friend plays back outgoing message.

Post conditions: Busy Friend listens to information recorded in answering machine.
Alternative Flow of Events: None
Assumptions: None

**Activity Diagram:**



## Expanded Use Case



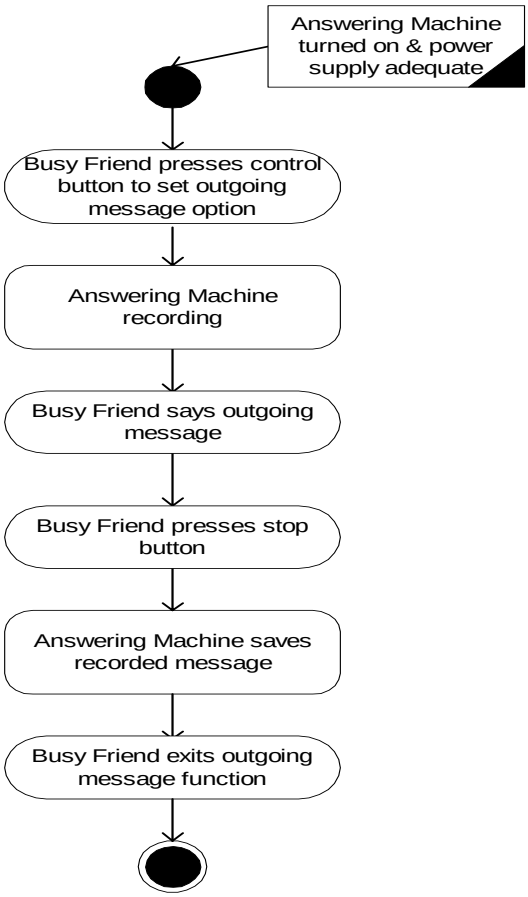

**USE CASE 2**

**Use Case 2.1: Record Outgoing Message**
Primary Actors: Busy Friend
Description: Busy Friend records outgoing message in Answering Machine.
Preconditions: Answering machine is turned on and has adequate power source.
Flow of Events: To record outgoing message

1. Press the control button to set outgoing message option.
2. Record outgoing message
3. Save outgoing message
4. Exit outgoing message function.

Post conditions: Personal outgoing message has been recorded.
Alternative Flow of Events: None
Assumptions: Default outgoing message is from Answering Machine

**Activity Diagram:**




**Use Case 2.2: Set Settings**
Primary Actors: Busy Friend
Description: Busy friend set personal settings in answering machine
Preconditions: Answering Machine is turned on and has adequate power source.
Flow of Events: To set personal settings

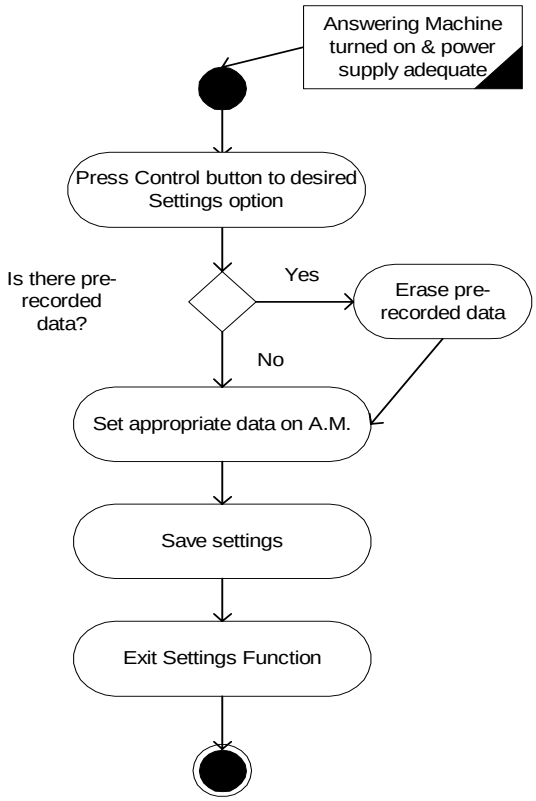
1. Press control button to desired settings option (security code, number of rings, date and time, volume)
2. Record or set appropriate data
3. Save settings
4. Exit settings function

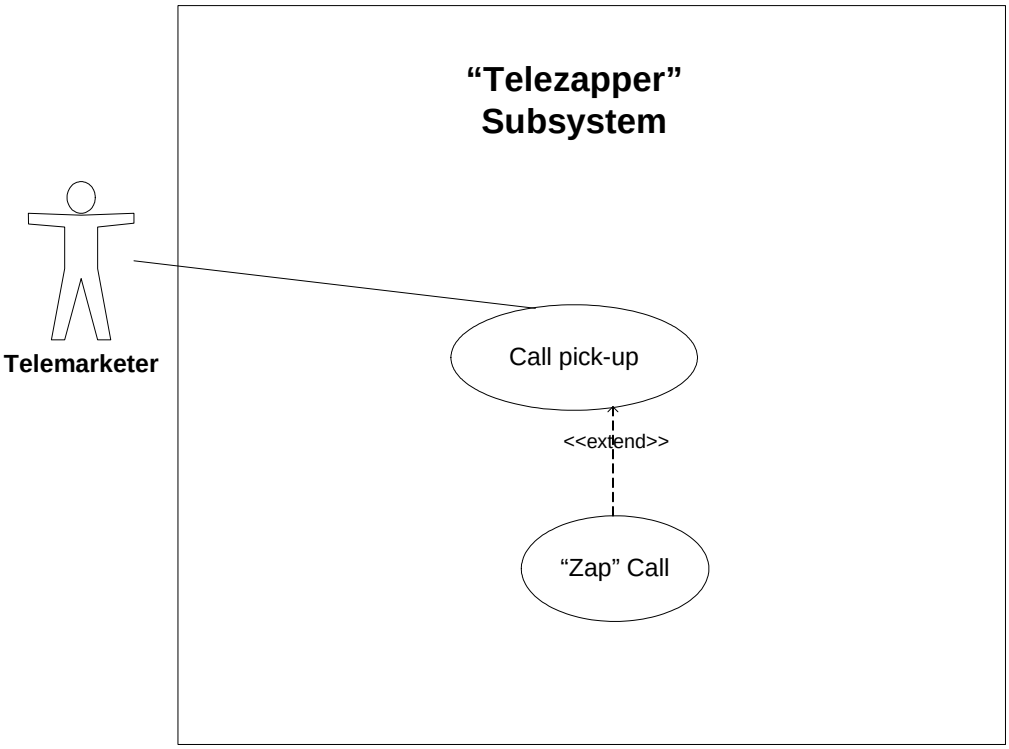
Post conditions: Personal settings for answering machine have been set.
Alternate Flow of Events: Already has previously recorded settings.

1. Press control button to desired settings option.
2. Erase pre-recorded data
3. Record new data
4. Save settings
5. Exit settings function

Assumptions: None

**Activity Diagram:**



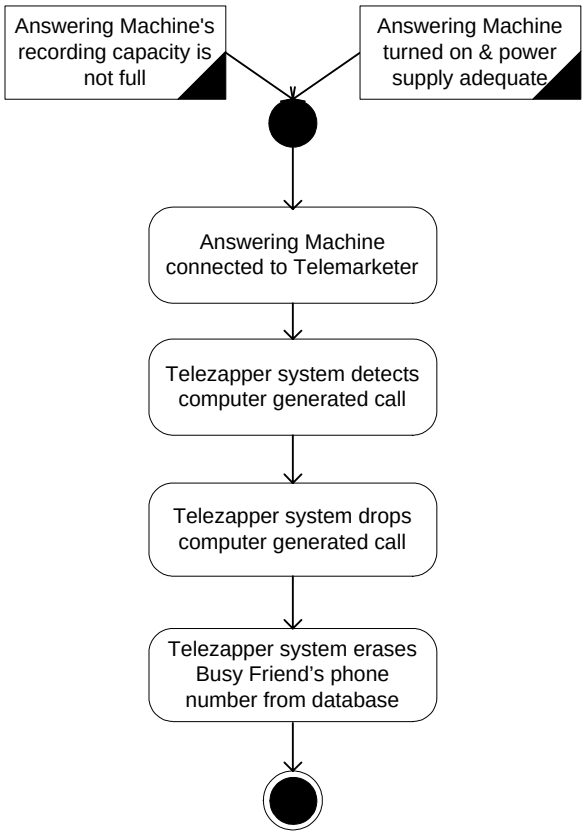

**USE CASE 3**

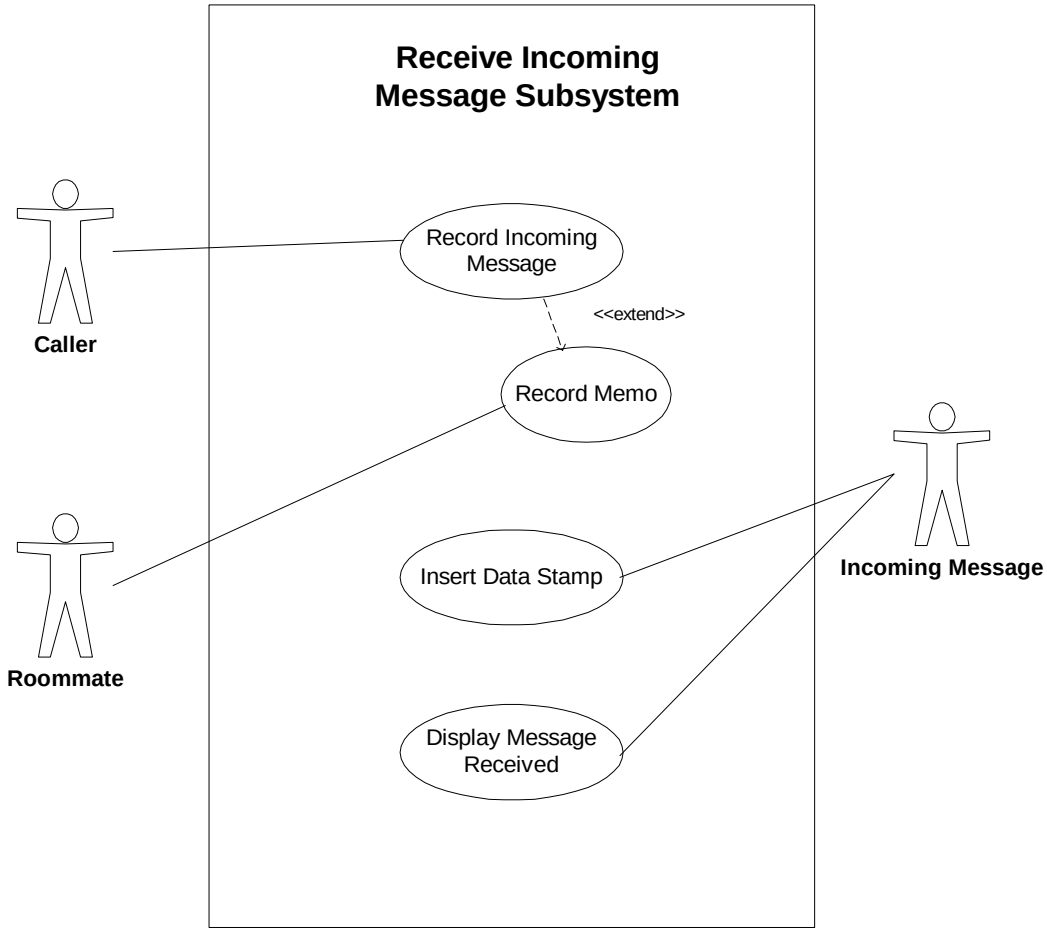
**Use Case 3.1: "Zap" Computer Generated Phone Call**
Primary Actors: Telemarketer
Description: Answering machine picks up call from Telemarketer. Telezapper system detects phone call, drops the call, and erases Busy Friend's phone number from the Telemarketer's computer database.
Precondition: The Answering Machine recording capacity is not full. Answering Machine is turned on and has adequate power source.
Flow of Events: Telezapper system "zaps" Telemarketer's computer generated phone call

1. Telemarketer calls Busy Friend from computer database.
2. Telezapper system detects the computer generated phone call.
3. Telezapper system drops the computer generated phone call.
4. Telezapper system erases Busy Friend's phone number from Telemarketer's computer database.

Assumptions: Busy Friend unavailable.

**Activity Diagram:**






**USE CASE 4**

**Use Case 4.1: Record Incoming Message**
Primary Actors: Caller, Roommate
Description: Answering Machine picks up call for Caller to record message for Busy Friend.
Precondition: The Answering Machine recording capacity is not full. Answering Machine is turned on and has adequate power source.
Flow of Events: Caller records incoming message

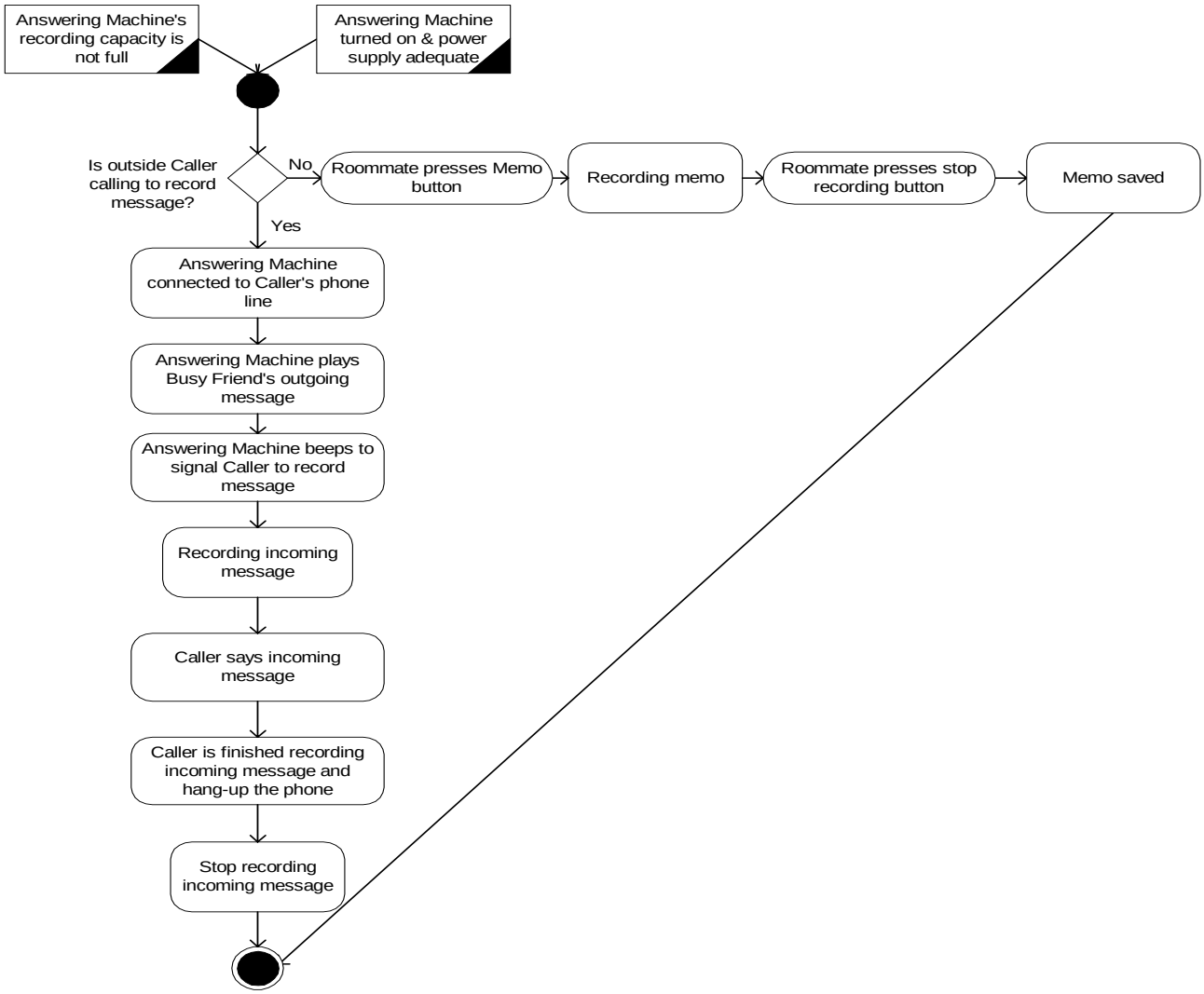
1. Caller hears outgoing message from Busy Friend in Answering Machine.
2. Caller hears a beep to signal for recording his/her incoming message
3. Caller finishes recording incoming message
4. Caller hangs up the call.

Post conditions: Incoming message has been recorded.
Alternative Flow of Events: Recording Memo in Answering Machine

1. Hit Memo button in answering machine.
2. Record Memo
3. Save Memo
4. Exit Memo function.

Assumptions: Busy Friend unavailable

**Activity Diagram:**




**Use Case 4.2: Insert Data Stamp**

Primary Actors: Message

Description: Answering Machine stamps the date and time on incoming message received.

Preconditions: Settings has been pre-recorded. Answering Machine is turned on and has adequate power source.

Flow of Events: Insert Data Stamp on message.

1. Answering Machine records incoming message.
2. Answering Machine records time and date message was received.

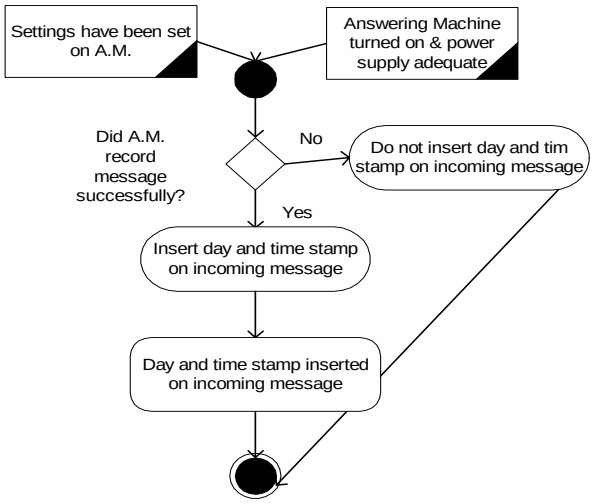
Post conditions: Data stamp has been recorded.

Alternative Flow of Events: Data stamp recorded on Caller ID.

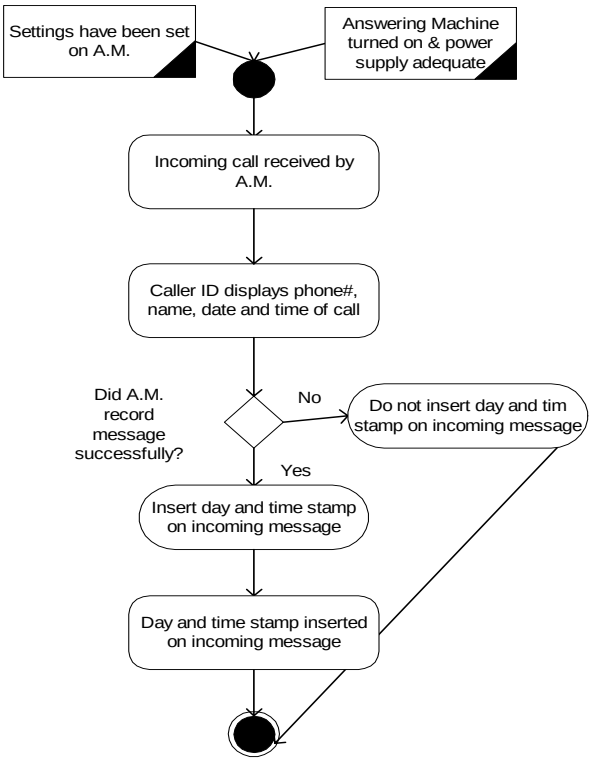
1. Answering Machine records Name of Caller, phone number, date and time on LCD screen.

Assumptions: None

**Activity Diagram:**




Insert Data Stamp




Alt: Caller ID data stamp

**Use Case 4.3: Display Incoming Message Received**

Primary Actors: Message

Description: Answering Machine displays new incoming messages received in display.

Preconditions: Answering Machine picked up Caller's phone call for Busy Friend. Answering Machine is turned on and has adequate power source.

Flow of Events: New incoming message displayed on answering machine screen.

1. Answering Machine will display number of new incoming messages in screen.

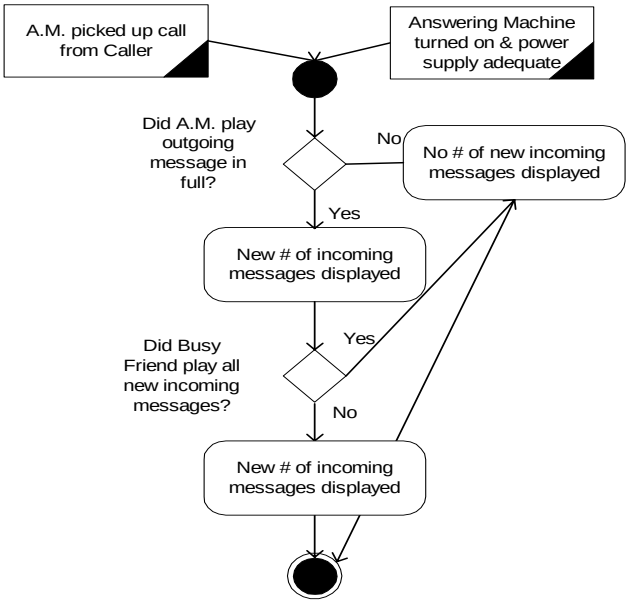
Post conditions: New messages are displayed in the screen of Answering Machine

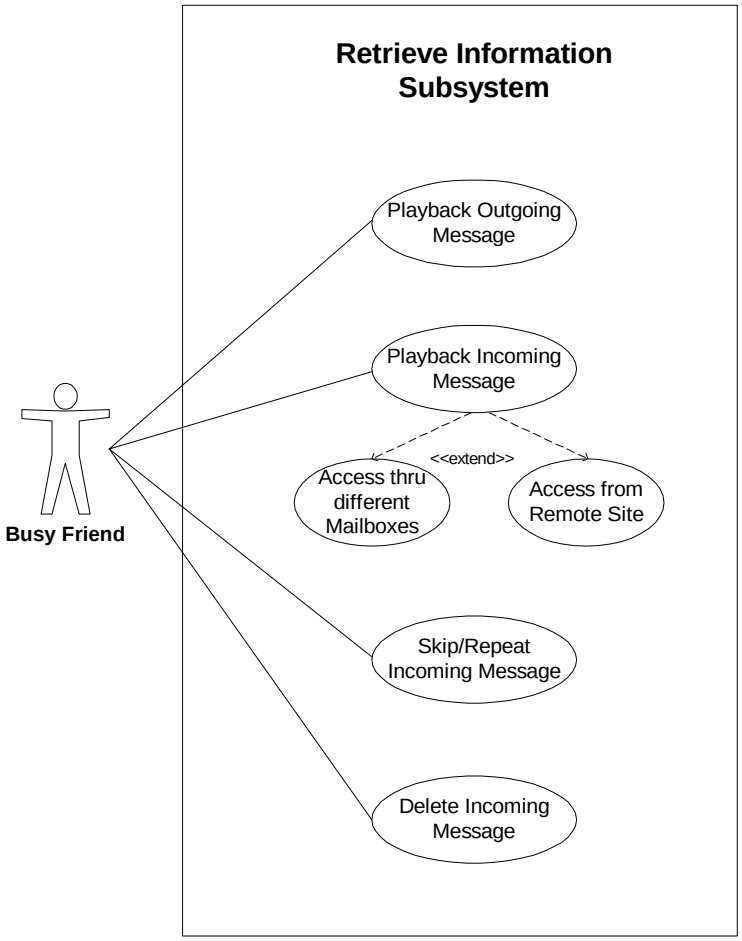
Alternative Flow of Events: No messages were left or all new messages have been heard

1. If Answering Machine plays all of outgoing message before Caller hangs up, the screen displays 1 new message but blank.
2. If Answering Machine does not finish playing outgoing message before Caller hangs up, the screen will display 0 new messages.
3. If all new incoming messages have been played, 0 messages will be displayed on screen.

Assumptions: None

**Activity Diagram:**



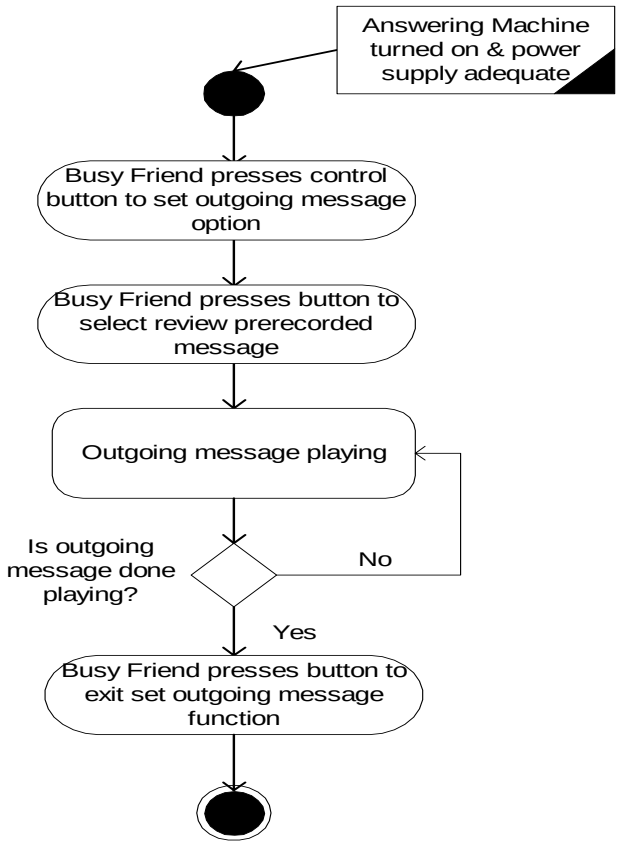

**USE CASE 5**

**Use Case 5.1: Play Outgoing Message**
Primary Actors: Busy Friend
Description: Busy friend plays back recorded outgoing message.
Preconditions: Answering Machine is turned on and has adequate power source.
Flow of Events: To playback outgoing message

1. Press control button to set outgoing message option
2. Review prerecorded message (default or previously recorded outgoing message.
3. Exit set outgoing message function.

Post conditions: Outgoing message has been reviewed and is satisfactory
Alternative Flow of Events: None
Assumptions: Default outgoing message is from Answering Machine

**Activity Diagram:**




**Use Case 5.2: Playback Incoming Messages**
Primary Actors: Busy Friend
Description: Busy Friend plays back incoming messages recorded by Answering Machine.
Preconditions: Answering Machine records incoming message properly. There was adequate recording space in answering machine. Answering Machine is turned on and has adequate power source.
Flow of Events: Busy Friend plays back incoming messages.

1. Press Play button if new incoming messages are displayed in Answering Machine screen.
2. Press Play button if Busy Friend wants to hear previously heard, unerased incoming messages.

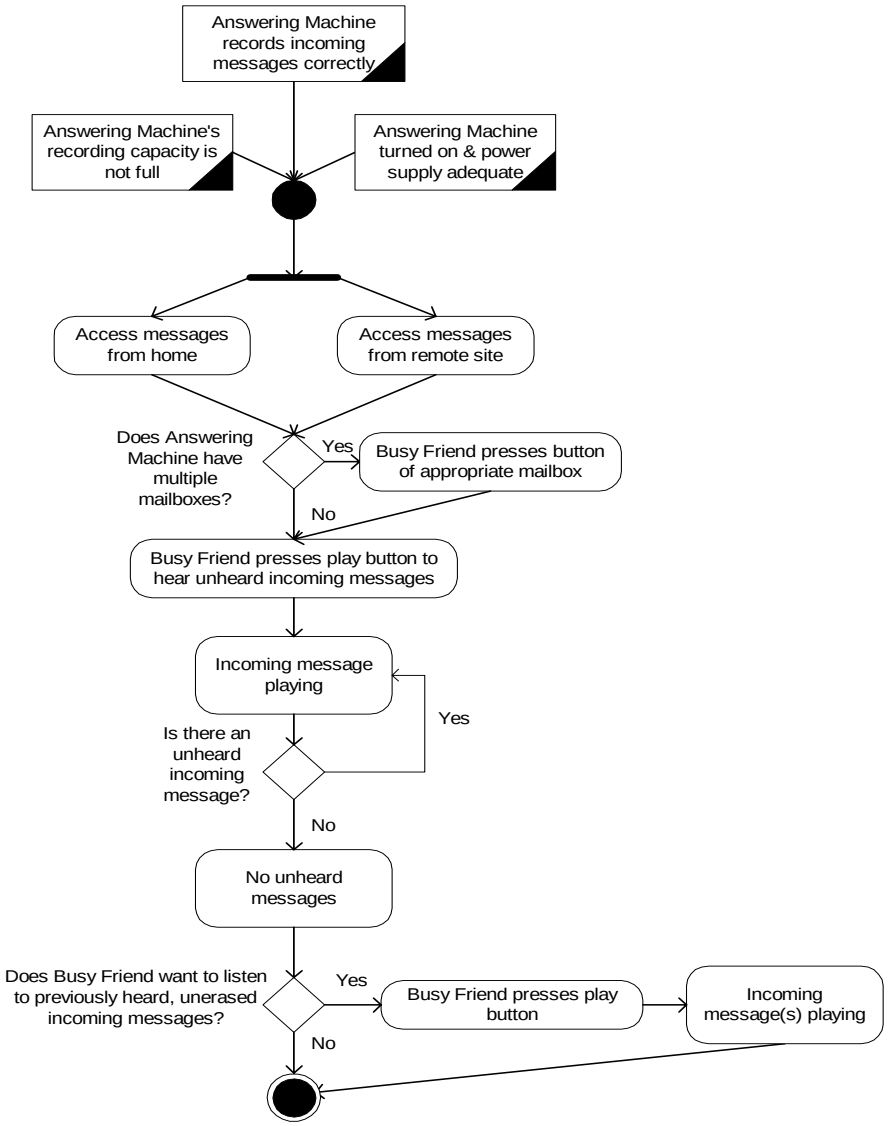
Post conditions: Busy Friend listens to incoming messages.

Alternative Flow of Events: Multiple Mailboxes.

1. Press appropriate Mailbox button in answering Machine.
2. Press Play button if new incoming messages are displayed in Answering Machine screen.
3. Press Play button if Busy Friend wants to hear previously heard, unerased incoming messages.

Assumptions: None

**Activity Diagram:**

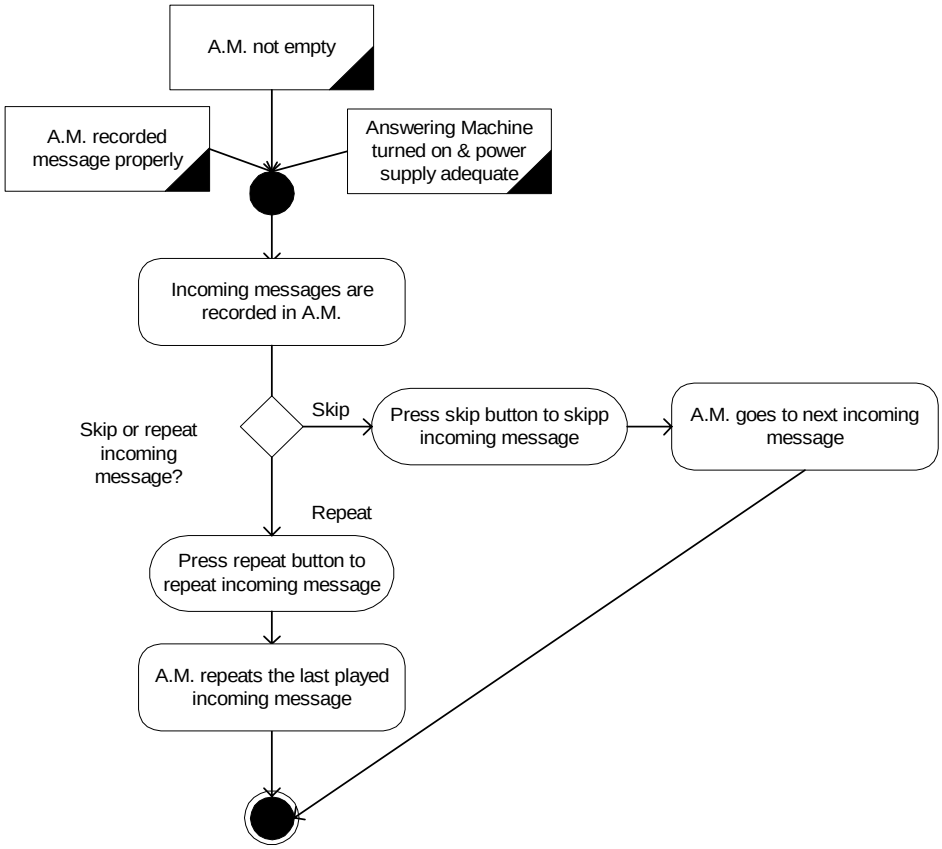


**Use Case 5.3: Repeat/Skip Incoming Messages**
Primary Actors: Busy Friend
Description: Busy Friend can repeat/skip messages recorded in Answering Machine.
Preconditions: Answering Machine recorded incoming messages properly. Answering Machine is not empty. Answering Machine is turned on and has adequate power source.
Flow of Events: Busy Friend repeats/skips incoming messages.

1. Busy Friend hits repeat button to repeat message.
2. Busy Friend hits skip button to skip message.

Post conditions: Busy Friend listens to incoming message.
Alternative Flow of Events: None
Assumptions: None

**Activity Diagram:**

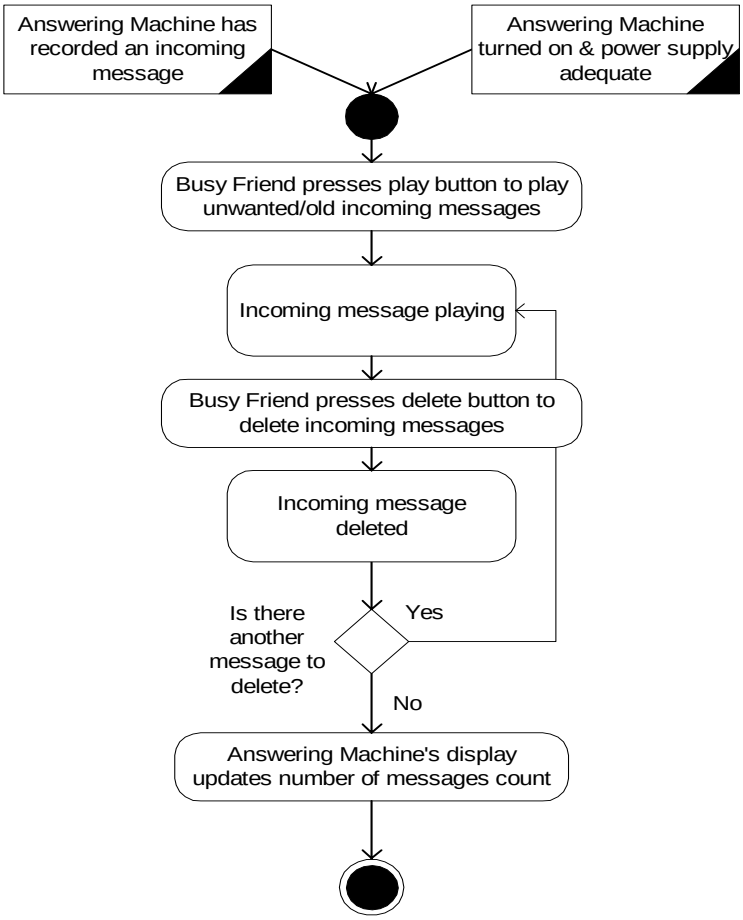



**Use Case 5.4: Delete Incoming Message**
Primary Actors: Busy Friend
Description: Busy Friend deletes unwanted messages from Answering Machine.
Preconditions: Answering Machine has recorded incoming messages. Answering Machine is not empty. Answering Machine is turned on and has adequate power source.
Flow of Events: Busy friend deletes messages.

1. Busy Friend plays unwanted/old incoming message.
2. Busy Friend hits delete button to delete message.
3. Answering Machine notifies Busy Friend that message has been deleted.

Post conditions: No more messages to delete
Alternative Flow of Events: None
Assumptions: None

**Activity Diagram:**



## 4. Generation of Requirements from Use Cases

Once use cases and scenarios have been developed, the conditions that must be present for the capabilities to exist can be determined. These conditions form the system requirements.

### High-level System Requirements from Use Cases

Requirements should be organized into a hierarchy. A hierarchy of requirements provides concise specifications with few explanations needed. Also, stating requirements in a hierarchy form provides benefits during the testing phase of the development lifecycle. The high-level requirement can be assumed fulfilled if all sub-requirements are successfully met. The high-level requirements for the answering machine system, which were developed using the use cases, are shown in Table 1.

Table 1: High-level System Requirements

| High Level (Level 1) Requirements from Use Cases |
|---|
| 1. The system shall record and maintain messages at all times.<br>2. The system shall allow user to personalize outgoing message and settings.<br>3. The system's interface shall be easy to use.<br>4. The system must interface with a standard telephone.<br>5. The system shall record messages accurately.<br>6. The system should record messages internally (not through the phone).<br>7. The system shall play recorded messages clearly and audibly.<br>8. The system shall store recorded messages securely.<br>9. The system should be accessible remotely.<br>10. The system shall have an adequate amount of recording capacity.<br>11. The system should provide calling information in addition to recorded message.<br>12. The system shall indicate the status of recorded messages.<br>13. The system shall be a manageable size to store.<br>14. The system should be able to eliminate telemarketers.<br>15. The system should be usable by vision or hearing impaired user. |

### Low-level System Requirements

The high-level system requirements can be broken down further into low-level requirements. The hierarchy of requirements with the low-level requirements is shown in Table 2.

Table 2: Low-level System Requirements

| Level 1 | Low Level Requirements (Levels 2, 3, & 4) | Importance | | | | |
|---|---|---|---|---|---|---|
| | | A | B | C | D | E |
| 1 | *1.1 The system shall contain a connector for the AC adapter. | 9 | 9 | 9 | 9 | 9 |
| | 1.2 The system shall contain rechargeable batteries that can be recharged inside the system via an included AC/DC adapter. | 0 | 0 | 9 | 0 | 0 |
| | *1.3 The system shall also be able to be powered by a standard AC electrical outlet using the included AC/DC adapter. | 9 | 9 | 9 | 9 | 9 |
| | 1.4 The system shall be able to operate for 36 continuous hours via a 9-volt rechargeable battery. | 0 | 6 | 9 | 3 | 3 |
| 2 | *2.1 The user shall be able to record a personalized outgoing message. | 9 | 9 | 9 | 9 | 9 |
| | 2.2 The user shall be able to determine the number of rings before the system intercepts the call. | 5 | 9 | 9 | 3 | 9 |
| 3 | *3.1 The system shall have easy to use interfaces for “skip”, “play”, “repeat”, “stop”, “pause”, “record” and “delete.” | 9 | 9 | 9 | 9 | 9 |
| | 3.2 The system should have easy to use interfaces for “intercom”, and “memo.” | 0 | 9 | 9 | 6 | 6 |
| | *3.3 The system’s interface layout must be easy to understand and self-explanatory. | 9 | 9 | 9 | 9 | 9 |
| | 3.4 The system’s interface shall contain input devices that are appropriately spaced out from one another. | 6 | 7 | 8 | 6 | 9 |
| 4 | 4.1 The system shall work with all telephones (cordless and corded) that meet the latest FCC standards. | 9 | 0 | 0 | 0 | 0 |
| | *4.2 The system shall contain molded channels for convenient cable routing pathways. | 9 | 9 | 9 | 9 | 9 |
| | *4.3 The system shall contain telephone line “in” and “out” jacks. | 9 | 9 | 9 | 9 | 9 |
| 5 | *5.1 The system shall have outstanding sound quality. | 9 | 9 | 9 | 9 | 9 |
| 6 | 6.1 The system should record internal memos. | 0 | 9 | 9 | 6 | 6 |
| | *6.2 The system shall contain a microphone. | 9 | 9 | 9 | 9 | 9 |
| 7 | *7.1 The system shall allow volume adjustment. | 9 | 9 | 9 | 9 | 9 |
| | *7.2 The system shall have lighting indicators. | 9 | 9 | 9 | 9 | 9 |
| | *7.2.1 The system shall have a lighting indicator for when messages have been recorded. | 9 | 9 | 9 | 9 | 9 |
| | 7.2.2 The system should have light up buttons. | 0 | 5 | 9 | 5 | 9 |
| | *7.3 The system display shall have at least a 14 pt. font display | 9 | 9 | 9 | 9 | 9 |
| 8 | *8.1 The system shall secure access to messages. | 9 | 9 | 9 | 9 | 9 |
| | 8.1.1 The system should require the user to enter a password code. | 0 | 6 | 9 | 5 | 5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 8.1.2 The system should allow additional users to setup individual password code. | 0 | 0 | 9 | 0 | 0 |
| | 8.1.3 The system should validate password code before playing messages. | 0 | 6 | 9 | 5 | 5 |
| | *8.2 The system shall not allow recorded messages to be edited or altered. | 9 | 9 | 9 | 9 | 9 |
| 9 | 9.1 The system should be accessible from remote sites. | 0 | 9 | 9 | 7 | 7 |
| 10 | *10.1 The system shall allow for a minimum recording time of 40 minutes for incoming messages. | 9 | 9 | 9 | 9 | 9 |
| | *10.2 The system shall allow for a maximum recording time of 10 minutes for outgoing messages. | 9 | 9 | 9 | 9 | 9 |
| | 10.3 The system shall have multiple mailboxes to store incoming messages. | 0 | 9 | 9 | 9 | 9 |
| 11 | 11.1 The system shall have a multi-digit display that must show the number of new messages. | 9 | 9 | 9 | 9 | 5 |
| | 11.2 The system should have a display that must show the elapsed time, caller information. | 4 | 9 | 9 | 9 | 5 |
| | *11.3 The system shall date-stamp recorded messages. | 9 | 9 | 9 | 9 | 9 |
| 12 | *12.1 The system shall indicate current settings currently used. | 9 | 9 | 9 | 9 | 9 |
| | 12.2 The system shall display the number of messages recorded. | 9 | 9 | 9 | 9 | 5 |
| 13 | *13.1 The system shall be able to be carried easily by all adults. | 9 | 9 | 9 | 9 | 9 |
| | 13.1.1 The maximum weight for the entire system should not exceed 16 oz. | 9 | 9 | 9 | 7 | 7 |
| | *13.2 The system shall be stored within a manageable area. | 9 | 9 | 9 | 9 | 9 |
| | 13.2.1 The maximum dimensions of the system should be 1.5”x5.2”x6.0”. | 9 | 9 | 9 | 7 | 7 |
| | *13.2.2 The system’s antenna shall not extend past 4” off of the base. | 9 | 9 | 9 | 9 | 9 |
| | 13.2.3 The system’s antenna should be retractable. | 7 | 7 | 7 | 7 | 7 |
| 14 | 14.1 *The system should be able to detect computer generated calls. | 0 | 9 | 9 | 9 | 9 |
| | 14.2 *The system should be able to drop computer generated calls. | 0 | 9 | 9 | 9 | 9 |
| | 14.3 *The system should be able to remove the user’s phone number in the telemarketer’s calling list. | 0 | 9 | 9 | 9 | 9 |
| 15 | 15.1 The system should be usable by a vision-impaired user. | 0 | 0 | 0 | 0 | 9 |
| | 15.1.1 The system shall employ Braille. | 0 | 0 | 0 | 0 | 9 |
| | 15.1.2 The system shall have audio status and | 0 | 0 | 0 | 0 | 9 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | prompts.<br>15.2 The system should be usable by a hearing-impaired user.<br>15.2.1 The system shall contain a visual display of status, prompts, and caller information.<br>15.2.2 The system shall use lights to guide user.<br>15.2.3 The system should be able to print text messages. | 0<br>0<br>0<br>0 | 0<br>0<br>0<br>0 | 0<br>0<br>0<br>0 | 9<br>9<br>9<br>8 | 0<br>0<br>0<br>0 |

Although each product in the family of answering machines possess a unique set of requirements, it is important to develop the requirements using the same requirements hierarchy. Developing requirements for each product in the same framework provides a clear distinction between different products and promotes common test procedures. Including an importance for each requirement by each product shows the distinction between products. The importance level prioritizes requirements for each product. The low-level requirements for the answering machine family of products were assigned an importance level ranging from zero to nine, which corresponds from low to high importance, respectively. The products, which are labeled A through E, correspond to the product variants presented in the section 6, Figure 7 (answering machine without phone, phone with three mailboxes, phone with five mailboxes, hearing impaired, vision impaired). With importance levels assigned, the variations between products become apparent.

In addition, assigning a level of importance for each requirement by each product identifies architectural drivers. Architectural drivers are requirements that are common for the entire family and therefore are requirements that have the highest level of importance for all platforms. In this case, the architectural drivers all have a level of nine for importance and are distinguished further with an asterisk next to the requirement number. Any change in an architectural driver will affect the entire family. Therefore, architectural driver requirements become the most important requirements and drive the remainder of the design process.

**Requirements Traceability**

The mapping of the generated requirements with their use case basis is shown in Table 3.

Table 3: Requirements Traceability Matrix

| | | Requirements | |
|---|---|---|---|
| Use Case | Scenario | Level 2 | Level 3 |
| 1. Turn answering machine on/off | 6.1 | 1.1-1.4 | |
| 2. Set data | 2.2, 4.1-4.6, 5.1 | 2.1-2.2, 3.1-3.4, 12.1 | 15.1.1, 15.1.2, 15.2.1-15.2.3 |

| | | | |
|---|---|---|---|
| 3. Pick-up phone call | 5.1 | 14.1-14.3 | |
| 4. Receive incoming message | 2.1 | 6.1, 6.2, 10.1-10.3 | |
| 5. Retrieve information | 1.1, 1.2, 2.3, 4.1-4.6 | 5.1, 7.1, 7.3, 11.1-11.3, 12.2 | 7.2.1, 7.2.2, 8.1.1-8.1.3, 9.1 |

## 5. Abstraction of System Models

The high level models of system structure and system behavior of the platform based design for the answering machine is represented here. The system structure shows the components involved in the answering machine product, while the system behavior models show the simplified behavior of the platform design and the product variants features of an answering machine system.

### System Structure

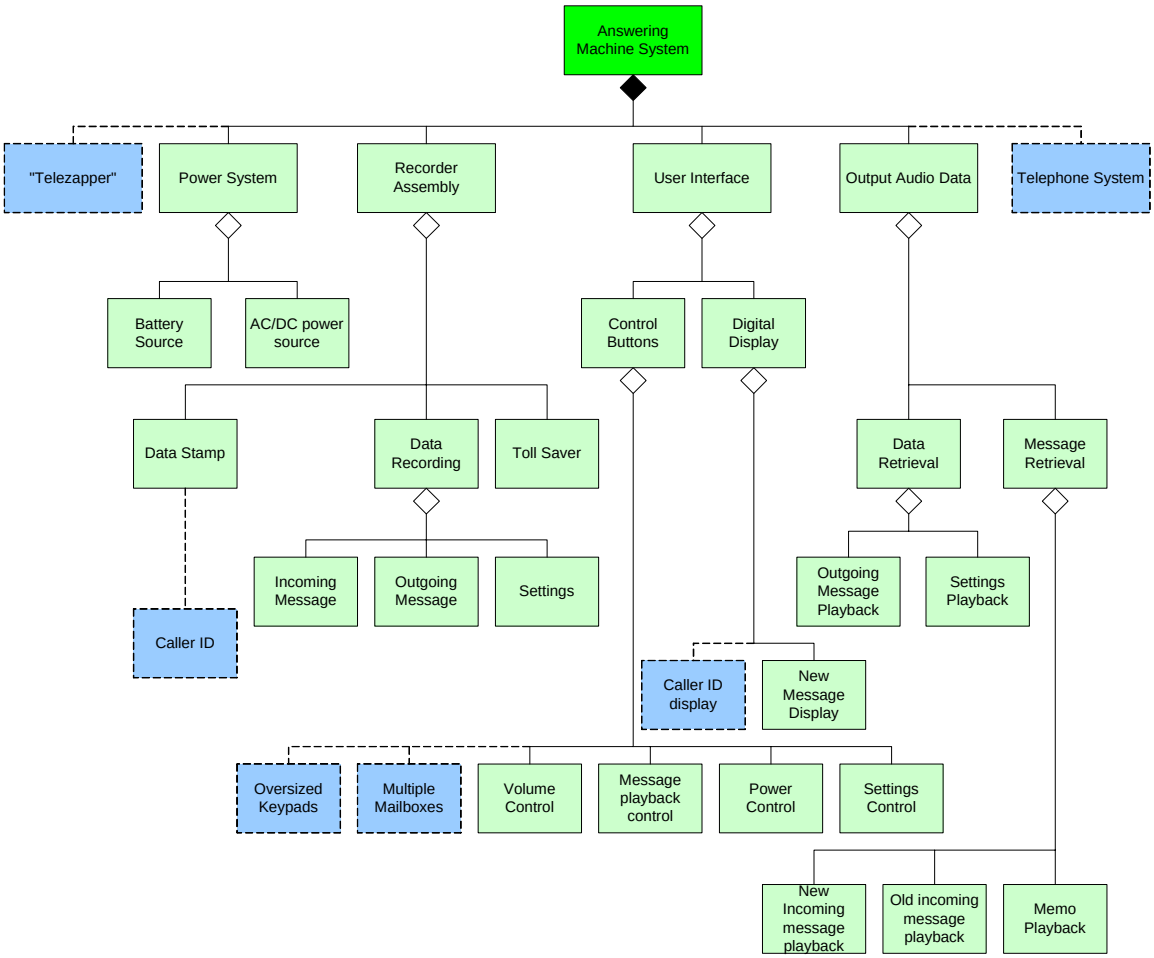



Figure 2

The Answering Machine system is represented in this system structure model with the subsystem hierarchies included. The green blocks represent the core features of the platform design of the answering machine. The blue blocks represent the extended features of the different models of the answering machine product line.

**Models of System Behavior**

Sequence diagram for the platform based design answering machine.

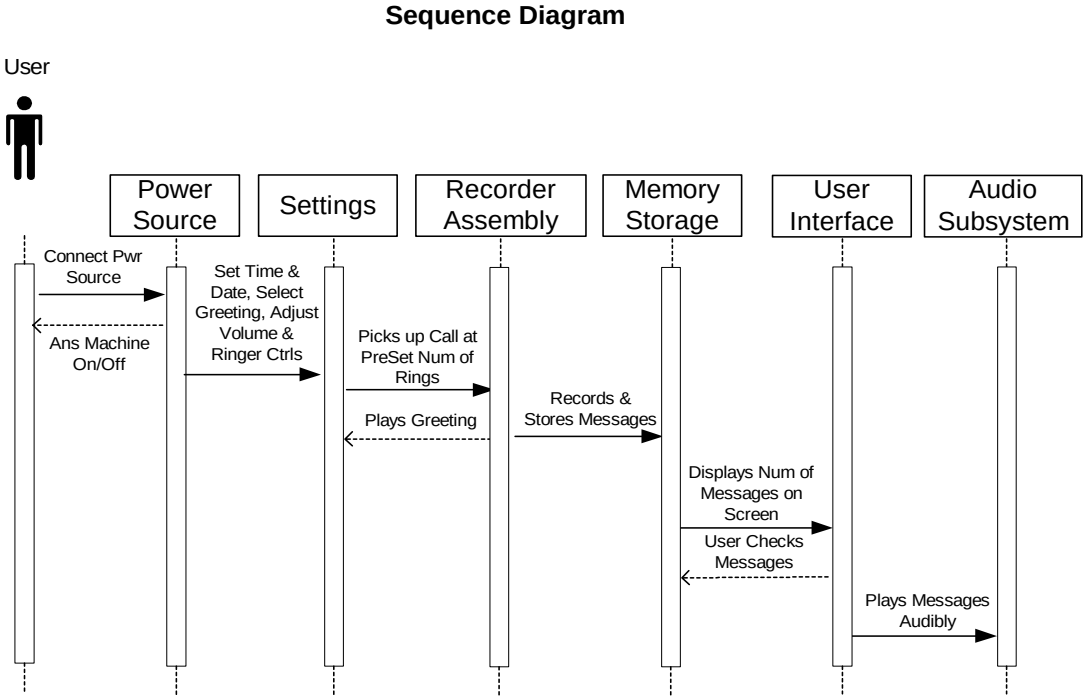



Figure 3

Sequence diagram for extended features for the answering machine product line.

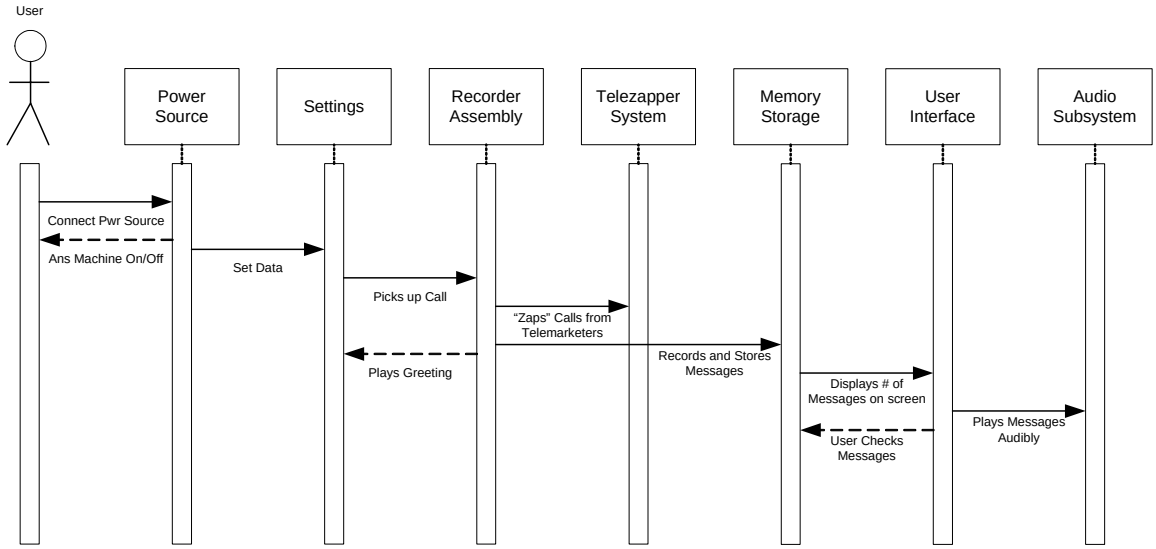



Figure 4

System State Chart Diagram for Answering Machine Product line.

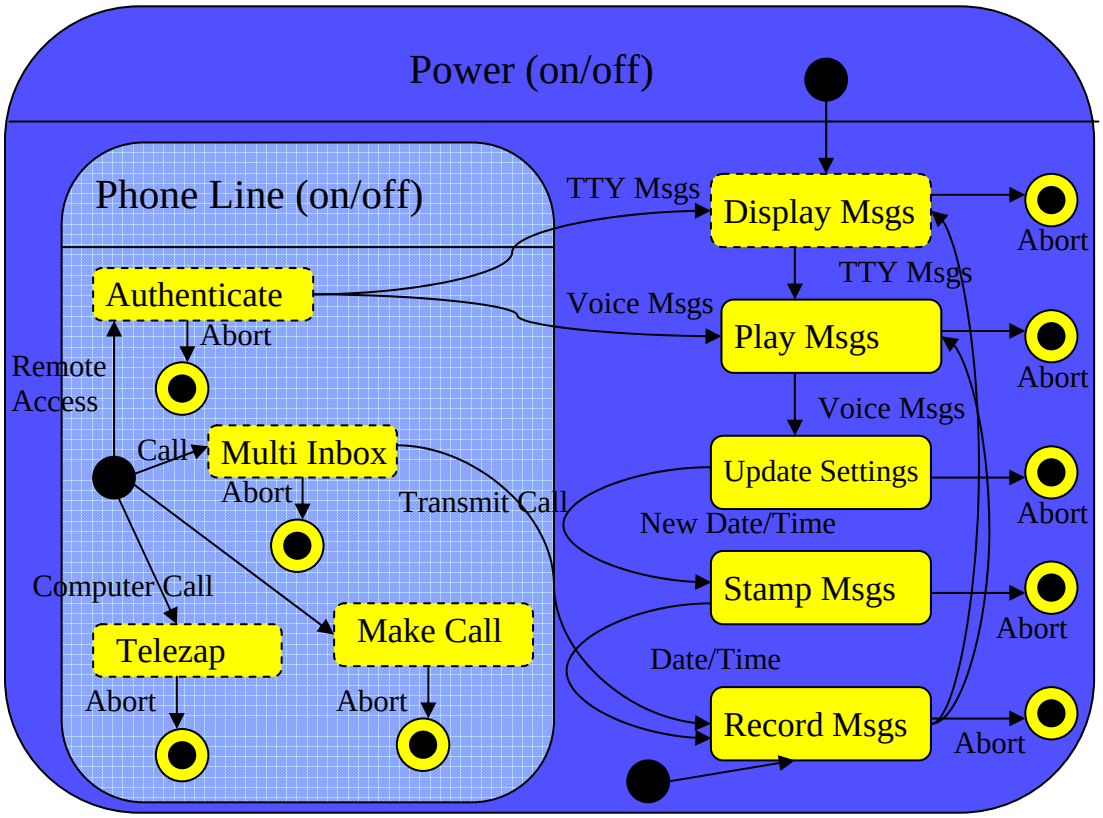



Figure 5

**System Logical Design**

This logical design schematic portrays the answering machine system structure mapped into its behavior for the overall capabilities of the answering machine product line.

Figure 6 shows the Answering Machine System's Logical Design.

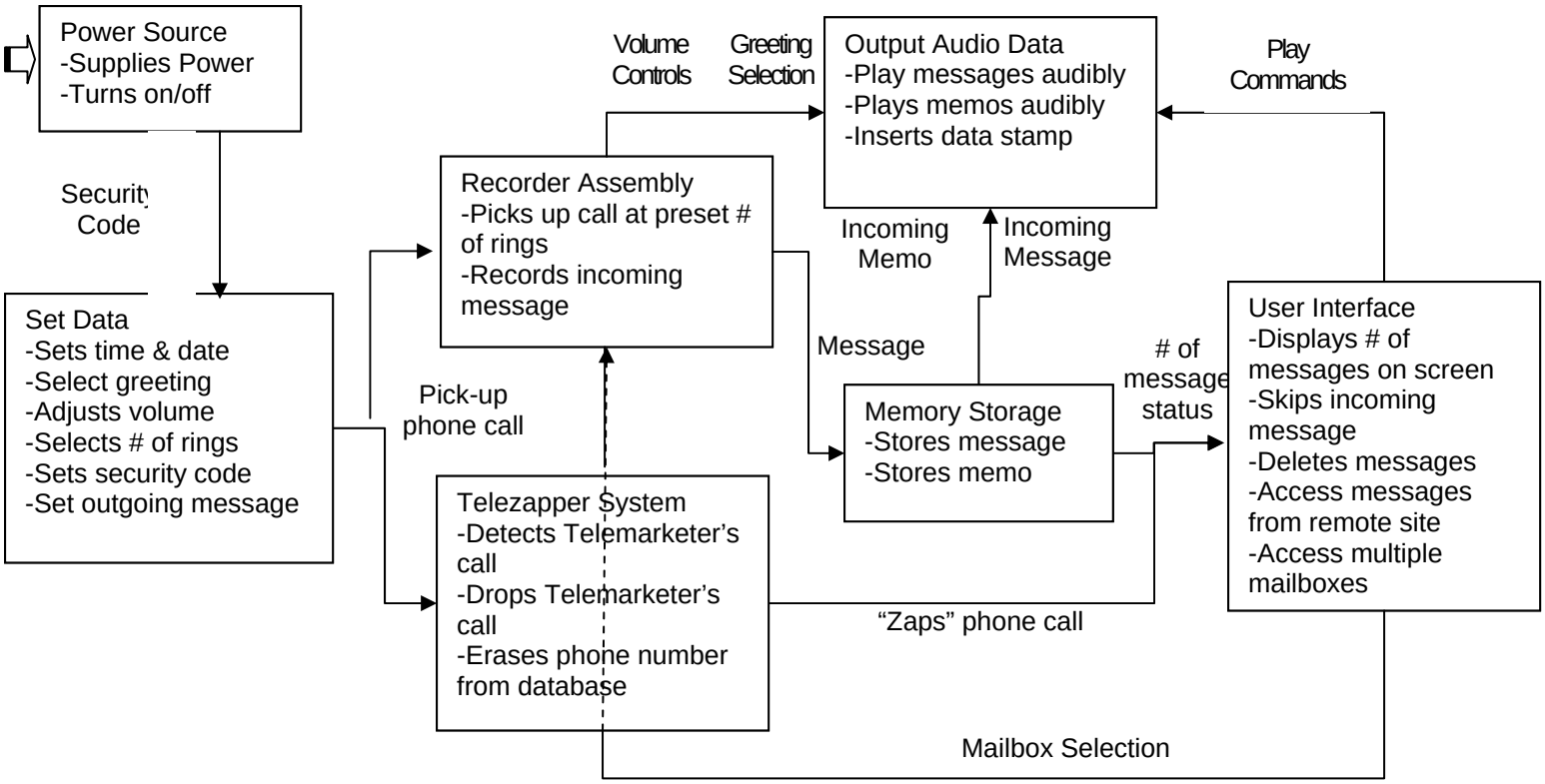



Figure 6

**6. Family of Answering Machine by Features**

This section includes a description of all the features contained by each product family members. Of particular importance are the features that resulted from the Architectural Driver Requirements (marked with an asterisk), which are common across the family of answering machines.

Notice that the family's "Platform" is the Low-End answering machine product and it includes all of the Architectural Driver Requirements defined in the Requirements section. The rest of the family members are generated by adding extra features on top of the ones contained in the platform model.

PLATFORM DESIGN (LOW END)

The platform design answering machine includes following features:

Input Power Connector: Includes connector for AC adapter. (*1.1 AC connector)

Power Supply: Allows to be powered by a standard AC electrical outlet using the included AC/DC adapter. (*1.3 AC/DC adapter)

Greeting Recording: Allows for personalized outgoing message to be recorded. (*2.1 Personalized message)

New Message Playback: Allows for new messages to be played first. (*3.1 Button assigned functions).

Play, Skip and Repeat Functions: Allows the user to play or skip to a new or a previously played message by the touch of a button. The repeat function allows for a cumulative 5-second instant replay. (*3.1 Button assigned functions).

All/Individual Erase: Allows the user to delete single messages or all recorder messages at once. (*3.1 Button assigned functions).

Adjustable Volume Control: Allows the user hear every word from any recorded message. (*5.1 Outstanding sound quality requirement).

Friendly User Interface: Button layout is easy to understand and include self-explanatory labels. (*3.3 Easy layout).

Cable Routing: Contains molded channels for convenient cable routing. (*4.2 Cable channels).

Phone Jack Connectors: Contains “in” and “out” telephone line connectors. (*4.3 Phone line connections).

Adjustable Tone Control: Allows the user to hear and distinguish between similar sounding words whenever unclear messages are recorded. (*5.1 Outstanding sound quality requirement).

Microphone: Contains fixed microphone. (*6.2 Microphone).

Adjustable Volume Control: Allows the user to adjust volume of play messages. (*7.1 Volume adjustment).

Lighting Indicators: Contains light up indicators for on/off and blinking light to signal new messages. (*7.2 Lighting indicators and *7.2.1 New message indicator).

14-point Font LCD Display:  Allows for display of caller ID without scrolling. (*7.3 14-pt display).

Secure Access: Allows user to set up a security code to access messages. (*8.1 Secure access).

Message Integrity: The system does not allow the alteration of the recorded messages. (*8.2 No edition of alteration).

Memory:  Allows up to 40 minutes recording time for incoming messages. (*10.1 Maximum recording time).  Allow up to 10 minutes recording time for outgoing messages (*10.2 Maximum outgoing message).

Time/Day Stamp:  Stamps each incoming or missed call. (*11.3 Date-stamp).

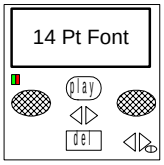
Display Settings: Displays settings currently used. (*12.1 Display settings).

Weight: Unit weight does not exceed 16 oz (*13.1 Easily transport).

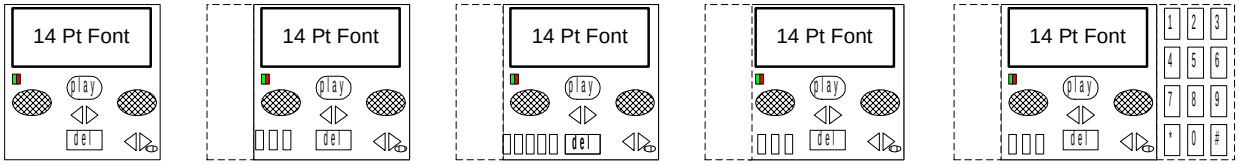
Dimensions: Unit size does not exceed 1.5 in X 5.2 in X 6.0 in. (*13.2 Easy storage).

Antenna: Unit possesses a retractable antenna. (*13.2.2 Antenna size).

## Platform-based Design




## Platform Variants




**A: Answering Machine (Low-End)**

**B: Phone and 3 Inboxes (Medium –End)**

**C: Phone and 5 Inboxes (High-End)**

**D: TTY Text Display, Phone and 3 Inboxes (TTY Text)**

**E: Large Keypad, Phone and 3 Inboxes (Braille)**

Figure 7: Product Family Key Features

MEDIUM END

The medium-end model includes all features contained in the platform model, plus the following features:

Computer Calls: Detects and drop computer generated calls.

Removes Telephone: Extracts user's telephone number from computer database.

HIGH-END MODEL

The high-end model answering machine includes all the features contained in the platform model, plus the following features:

Caller ID Memory and Dialer: Stores up to 50 most recent calls. Allows for auto dialing of any of the numbers in memory. Allows for visual and/or audible review.

Caller ID On Call Waiting: Displays caller ID information for call waiting calls, allowing the user to prioritize his/her calls

Separate Mail Boxes: Contains 5 separate voice invoices.

Toll Saver: When remote access, the machine will pick up on the first ring only if you have new messages. If not, the use can hang up and avoid toll charges.

Light up Buttons: Contains light up indicators for all features requiring user interface.

TTY TEXT MODEL

The TTY text model answering machine includes all the features contained in the platform model, plus the following features:

TTY Feature: Allows for voice messages to be translated into text, which are display in the 14-pt font LCD screen. The user is also allows to scroll down to read long messages.

Text Message Mail Boxes: Allows for TTY text message storage.

Light up Buttons: Contains light up indicators for all features requiring user interface.

BRAILLE MODEL

The Braille user model answering machine includes all the features contained in the platform model, plus the following features:

Audible Message Alert: Machine emits a distinct beeping sound when new messages have been stored.

Voice Announce Caller ID Option:  Announces caller's 10-digit telephone number between first and second rings.

Braille Buttons: All buttons use Braille type markings.

Large Keypad: Contains enlarge keypad to facilitate detection by the visually impaired.

## 7. Architectural Drivers for the Answering Machine Platform Design

The architectural drivers for the answering machine platform design were derived from the hierarchy of requirements.  The general requirements came from the analysis of customer needs for an answering machine.  The architectural drivers will be used as the basis of the baseline design for the answering machine product line.  From this list of architectural drivers, many alternative models and variations can be added on to the family of products for an answering machine.  The next table shows the requirements shared by all 5 of the answering machine products.

Table 4 shows the Architectural Driver requirements that are common to all 5 answering machine models.

Table 4: Architectural Driver Requirements

| Architectural Drivers | | | |
|---|---|---|---|
| **Level 1** | **Level 2** | **Level 3** | **Requirements** |
| 1 | 1.1 | | The system shall contain a connector for the AC adapter |
| | 1.3 | | The system shall also be able to be powered by a standard AC electrical outlet using the included AC/DC adapter |
| 2 | 2.1 | | The user shall be able to record a personalized outgoing message. |
| 3 | 3.1 | | The system shall have easy to use interfaces for “skip”, “play”, “repeat”, “stop”, “pause”, “record” and “delete” |
| | 3.3 | | The system’s interface layout must be easy to understand and self-explanatory |
| 4 | 4.1 | | The system shall work with all telephones (cordless and corded) that meet the latest FCC |
| | 4.2 | | The system shall contain molded channels for convenient cable routing pathways |
| | 4.3 | | The system shall contain adjustable telephone “in” and “out” jacks |
| 5 | 5.1 | | The system shall have outstanding sound quality |
| 6 | 6.2 | | The system shall contain a microphone |
| 7 | 7.1 | | The system shall allow volume adjustment |
| | 7.2 | | The system shall have lighting indicators |
| | | 7.2.1 | The system shall have a lighting indicator for messages successfully recorded |
| | 7.3 | | The system display shall have at least a 14 pt. font display |
| 8 | 8.1 | | The system shall secure access to messages |
| | 8.2 | | The system shall not allow recorded messages to be edited or altered |
| 10 | 10.1 | | The system shall allow for a minimum recording time of 40 minutes for incoming messages |
| | 10.2 | | The system shall allow for a maximum recording time of 10 minutes for outgoing messages |
| 11 | 11.3 | | The system shall date-stamp recorded messages |
| 12 | 12.1 | | The system shall indicate current settings currently used |
| 13 | 13.1 | | The system shall be able to be carried easily by all adults |
| | 13.2 | | The system shall be stored within a manageable area |
| | | 13.2.2 | The system’s antenna shall not extend past |

From this table, common components shared by all 5-product variants are determined. The components, although common to all product variants, can potentially vary in numbers based on specific requirements of each model.

Table 5: Component Comparison Matrix

| Component Comparison Matrix | | | | | |
|---|---|---|---|---|---|
| **Components** | **Low** | **Medium** | **High** | **Vision Impaired** | **Hearing Impaired** |
| AC adapter | 1 | 1 | 1 | 1 | 1 |
| Button functions | 1 | 1 | 1 | 1 | 1 |
| Telephone compatibility component | >1 | 1 | 1 | 1 | 1 |
| Cable routings | 1 | 1 | 1 | 1 | 1 |
| Sound component | 1 | 1 | 1 | 1 | 1 |
| Microphone | 1 | 1 | 1 | 1 | 1 |
| Volume component | 1 | 1 | 1 | 1 | 1 |
| LED indicators | 1 | 4 | 6 | 4 | 4 |
| 14 Pt. Font display | 1 | 1 | 1 | 1 | 1 |
| Security chip | 1 | 1 | 1 | 1 | 1 |
| Memory chip | 1 | 3 | 5 | 4 | 4 |
| Chassis | 1 | 1 | 1 | 1 | 1 |
| 4" Antenna | 1 | 1 | 1 | 1 | 1 |

This can also show process commonality through the identification of the common test methods for all the answering machine products. This allows for reuse of the platform design components and test methods for the different models of the answering machine product line. The goals of achieving economies of scale and standardized learning curve are made easier by identifying the architectural drivers.

Table 6: Preview of Verification Method Table

| Verif. Para. | Verif. Method | Description |
|---|---|---|
| v_4.3 | T | Plugs cables into both jacks. System fails if the cables do not connect. |
| v_7.3 | T | Plug LCD display to test laptop and run font test. All signals must be display in 14 pt. Font. |
| v_6.2 | T | Plug microphone component into test laptop containing voice wave samples. The amplification of the voice wave should be at least 1.5 times the signal at entry. |
| v_1.1 | T | User plugs AC adapter into connector. System fails if the AC adapter does not connect. |
| v_1.3 | T | Remove batteries and plug AC/DC adapter into a working electrical outlet. System fails if the system does not fully operate. |
| v_3.1 | T | Instruct user to select interface for each function designated. System fails if it takes the user longer than 1 minute to correctly identify interface. |
| v_3.3 | T | Instruct the user to perform a task, and with a stopwatch, measure the time that it takes to complete the task. System fails if this time is greater than 2 minutes for each task. |
| v_5.1 | T | Connect sound module to a sin wave generator and measure the amplitude of signal in oscilloscope. Any distortion of more than 10% will account as component failure. |
| v_7.1 | T | Plug speaker component into test laptop containing voice recording diagnostic program. Different volume options have been pre-selected wave samples. |
| v_8.1 | T | Plug secure access diagnostic program from test laptop. Several case data will be inputted into the system. |
| v_11.3 | T | Set test laptop to subject the system into different simulated call times. The system should reflect the correct date and time the message was left. |
| v_12.1 | T | Set test laptop to play with the different settings of the system. The system should reflect the test laptop's request. |

This is a continuation of process communality for the answering machine product line.

| Verif. Para. | Verif. Method | Description |
|---|---|---|
| v_5.1 | A | Record pitch and measure decibels while message is being recorded. Record pitch and measure decibels while the recorded message is being played back. System fails if the delta between the measurements exceeds 10%. |
| v_6.2 | D | Factory demonstration should include testing microphone option of every 1 in 1,000 machines. |
| v_7.1 | D | Factory demonstration should include testing volume adjustability option of every 1 in 1,000 machines. |
| v_11.3 | D | Factory demonstration will do sample testing on batch lots to test the system's data stamp function. 30 out of a 1000 failures generates a batch lot failure. |
| v_12.1 | D | Factory demonstration will do sample testing on batch lots to test current settings of the system. 3% failure of the lot generates a lot failure. |
| v_2.1 | D | User selects menu option to record message. User speaks into the microphone. The system converts sound waves into digital components. System fails if the system does not successfully complete the following: prompt user to record the message, covert sound into digital components, record complete message accurately, or play new message at the next outside phone call. |
| v_4.2 | D | User plugs cables into connection and routs them into the channel. System fails if the cables do not fit into channels or it is too difficult of a task to complete. |
| v_5.1 | D | Message is recorded into the system and played back to a sample size of ten users of varying ages and hearing abilities, which are representative of the user population. The sample must record what they heard on the message. System fails if any member of the sample is not able to correctly repeat the recorded message. |
| v_8.2 | D | Operate system and verify the integrity of the recorded message after the system settings have been modified and after power has been discontinued for 5 min. Test 1 in 1000 units |
| v_10.1 | D | Operate system and use stop watch to time the recording time limits of at least 1 in 1000 units. |
| v_10.2 | D | Operate system and use stop watch to time the greeting recording time limit of at least 1 in 1000 units. |
| v_13.1.1 | E | Using a weight scale, make sure the system's weight does not exceed 16 oz. |
| v_13.2.1 | E | Using a ruler, make sure the system's dimension and size don't exceed 1.5"X5.2"X6.0" |
| v_13.2.2 | E | Using a ruler, make sure the antenna of the system does not exceed 4". |
| v_13.2.2.1 | E | Visually inspect that the system has the internal antenna installed. |
| v_4.2 | E | See whether there is a continuous molded channel. System fails if channel is not continuous. |
| v_1.1 | E | See whether system has connection. System fails if there is no connection. |
| v_4.3 | E | See whether there are two jacks. System fails if two jacks are not present. |
| v_3.1 | E | Visually inspect that there is an interface for all functions with a connection to the appropriate circuit. System fails if this does not exist. |
| v_3.3 | E | Visually inspect that there is a unique interface for each function that is clearly labeled. System fails if this does not exist. |
| v_7.2 | E | Visually inspect that all indicators are easily identifiable. |
| v_12.2 | E | Visually inspect the system's LED indicators. The system should have all the light indicators working properly and must show the correct number of newly recorded messages. |
| v_7.2.1 | E | Visually inspect that recoded message indicator displays the right number of messages and lights-up. |

## 8. System Verification and Validation Plan

After requirements have been developed, one or more verification requirements should be developed for each requirement. Verification requirements determine whether or not a requirement has been achieved. The verification methods include:

- Testing (T): Undergoing a series of planned simulations
- Analysis (A): Using technical or mathematical models derived from scientific principles
- Demonstration (D): Operating under actual environment
- Examination (E): Inspecting non-functional requirements

### Verification Traceability Matrix (VTM)

A Verification Traceability Matrix (VTM) shows the verification methods and descriptions that correspond to a particular design requirement. The VTM for the system is shown below in Table 7.

Table 7: Answering Machine System Verification Traceability Matrix

| Reqt. | Title | T | A | D | E | Verification Para. | Verification Requirement |
|---|---|---|---|---|---|---|---|
| *1.1 | AC Adapter Connection | X | | | X | v_*1.1 | Test: User plugs AC adapter into connector. System fails if the AC adapter does not connect. Examination: See whether system has connection. System fails if there is no connection. |
| 1.2 | Rechargeable Batteries | | | X | X | v_1.2 | Demonstration: User places uncharged batteries in system and unplugs the system after six hours. System fails if the system does not fully operate after being unplugged. Examination: See whether the system contains batteries. System fails if there are no batteries. |
| *1.3 | AC Electrical Outlet Power | X | | | | v_*1.3 | Remove batteries and plug AC/DC adapter into a working electrical outlet. System fails if the system does not fully operate. |
| 1.4 | Battery Operation | | | X | | v_1.4 | User unplugs AC/DC adapter from fully charged system. System fails if the system does not operate fully for 36 consecutive hours. |
| *2.1 | Outgoing Message Personalization | | | X | | v_*2.1 | User selects menu option to record message. User speaks into the microphone. The system converts sound waves into digital components. System fails if the system does not successfully complete the following: prompt user to record the message, covert sound into digital components, record complete message accurately, or play new message at the next outside phone call. |
| 2.2 | Number of Rings Setting | | | X | | v_2.2 | User selects menu option to select the number of rings. The system accepts the input and adjusts the number of rings setting. After receiving an outside phone call, the system picks up after the new set number of tings. System fails if the system does not prompt the user to change the number of rings, adjust the settings for the input, or intercept an outside phone call after the set number of rings. |
| *3.1 | Usable Interfaces | X | | | X | v_*3.1 | Test: Instruct user to select interface for each function designated. System fails if it takes the user longer than 1 minute to correctly identify interface. Examination: Visually inspect that there is an interface for all functions with a connection to the appropriate circuit. System fails if this does not exist. |

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| 3.2 | "Intercom" and "Memo" Interfaces | | | X | X | v_3.2 | Examination: Visually inspect that there is an interface with a connection to the appropriate circuits. System fails if this does not exist. Demonstration: The user initiates the memo function and follows the prompts to record a memo. The system fails if the user cannot determine how to activate the memo function and/or cannot understand the promptings to successfully record a memo. |
| *3.3 | Interface Layout | X | | | X | v_*3.3 | Test: Instruct the user to perform a task, and with a stopwatch, measure the time that it takes to complete the task. System fails if this time is greater than 2 minutes for each task. Examination: Visually inspect that there is a unique interface for each function that is clearly labeled. System fails if this does not exist. |
| 3.4 | Interface Spacing | | X | | X | v_3.4 | Analysis: Collect sample of pointer finger diameters. Compare the diameter distribution the minimum combined spacing plus interface size. System fails if the finger diameter at 95% is greater than the minimum combination of spacing plus interface. Examination: Measure the spacing between all inputs devices. System fails if the spacing is less than 2 cm. |
| 4.1 | Telephone Compatibility | X | | | | v_4.1 | Randomly select two cordless and two corded telephones that meet FCC regulations. Connect the system to each telephone. System fails if the system does not fully function or if the telephone does not operate while connected to the system. |
| *4.2 | Cable Routing Channels | | | X | X | v_*4.2 | Demonstration: User plugs cables into connection and routs them into the channel. System fails if the cables do not fit into channels or it is too difficult of a task to complete. Examination: See whether there is a continuous molded channel. System fails if channel is not continuous. |
| *4.3 | "In" and "Out" Jacks | X | | | X | v_*4.3 | Test: Plugs cables into both jacks. System fails if the cables do not connect. Examination: See whether there are two jacks. System fails if two jacks are not present. |
| *5.1 | Sound Quality | X | X | X | | v_*5.1 | Test: Connect sound module to a sin wave generator and measure the amplitude of signal in oscilloscope. Any distortion of more than 10% will account as component failure. Analysis: Record pitch and measure decibels while message is being recorded. Record pitch and measure decibels while the recorded message is being played back. System fails if the delta between the measurements exceeds 10%. Demonstration: Message is recorded into the system and played back to a sample size of ten users of varying ages and hearing abilities, which are representative of the user population. The sample must record what they heard on the message. System fails if any member of the sample is not able to correctly repeat the recorded message. |
| 6.1 | Internal Memo Recording | X | | X | | v_6.1 | Test: Plug memory chip into test laptop containing voice wave samples. Chip must record voice wave with a minimum of 24 db (whisper). Demonstration: Factory demonstration should include testing the memo recording option of every 1 in 1,000 machines. |
| *6.2 | Microphone | X | | X | | v_*6.2 | Test: Plug microphone component into test laptop containing voice wave samples. The amplification of the voice wave should be at least 1.5 times the signal at entry. Demonstration: Factory demonstration should include testing microphone option of every 1 in 1,000 machines. |
| *7.1 | Adjustable Volume | X | | X | | v_*7.1 | Test: Plug speaker component into test laptop containing voice recording diagnostic program. Different volume options have been pre-selected. wave samples. Demonstration: Factory demonstration should include testing volume adjustability option of every 1 in 1,000 machines. |
| *7.2 | Indicators | | | | X | v_*7.2 | Visually inspect that all indicators are easily identifiable. |

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| *7.2.1 | Recorded Messages Indicator | | | | X | v_*7.2.1 | Visually inspect that recoded message indicator displays the right number of messages and lights-up. |
| 7.2.2 | Light-up Buttons | | | | X | v_7.2.2 | Visually inspect that all buttons light-up. |
| *7.3 | 14 pt. Font Display | X | | | | v_*7.3 | Plug LCD display to test laptop and run font test. All signals must be display in 14 pt. Font. |
| *8.1 | Secure Access | X | | | | v_*8.1 | Plug secure access diagnostic program from test laptop. Several case data will be inputted into the system. |
| 8.1.1 | Password Protection | X | | | | v_8.1.1 | Test Laptop exposes system to a predetermine number of passwords. |
| 8.1.2 | Multiple User Password | X | | | | v_8.1.2 | Test Laptop will provide multiple valid passwords. |
| 8.1.3 | Password Validation | X | | | | v_8.1.3 | System shall authenticate the valid passwords and display a failure message or menu options depending on authentication. |
| *8.2 | Integrity of Recorded Messages | | | X | | v_*8.2 | Operate system and verify the integrity of the recorded message after the system settings have been modified and after power has been discontinued for 5 min. Test 1 in 1000 units |
| 9.1 | Remote Access | X | | | | v_9.1 | Plug remote access diagnostic program from test laptop. Several case data will be inputted into the system. Predefined failures and successes will be recorded |
| *10.1 | Call Recording Time | X | | | | v_*10.1 | Operate system and use stop watch to time the recording time limits of at least 1 in 1000 units. |
| *10.2 | Greeting Recording Time | X | | | | v_*10.2 | Operate system and use stop watch to time the greeting recording time limit of at least 1 in 1000 units. |
| 10.3 | Multiple Mailboxes | | | X | | V_10.3 | Select Mailbox 1 and make sure that Mailbox 1's messages are played. Select a different mailbox and make sure that the messages for the other mailbox are played. |
| 11.1 | Display | | | | X | v_11.1 | Visually inspect the system's multi-digit display. The system should have all the light indicators working properly and must show the correct number of newly recorded messages. |
| 11.2 | Display | X | | | X | v_11.2 | Test: Plug the system's LCD/digital display to a test laptop and run several call scenarios. Make sure the system reflects the right scenario (caller) information. Examination: Visually inspect the system's LCD or digital display. System failure occurs if the display fails to reflect test information on its screen. |
| 11.3* | Data Stamp | X | | X | | v_*11.3 | Test: Set test laptop to subject the system into different simulated call times. The system should reflect the correct date and time the message was left. Demonstration: Factory demonstration will do sample testing on batch lots to test the system's data stamp function. 30 out of a 1000 failures generate a batch lot failure. |
| 12.1* | Settings | X | | X | | v_*12.1 | Test: Set test laptop to play with the different settings of the system. The system should reflect the test laptop's request. Demonstration: Factory demonstration will do sample testing on batch lots to test current settings of the system. 3% failure of the lot generates a lot failure. |
| 12.2* | Display | | | | X | v_12.2 | Visually inspect the system's LED indicators. The system should have all the light indicators working properly and must show the correct number of newly recorded messages. |
| 13.1.1* | Weight | | | | X | v_*13.1 | Using a weight scale, make sure the system's weight does not exceed 16 oz. |
| 13.2.1* | Size | | | | X | v_*13.2 | Using a ruler, make sure the system's dimension and size don't exceed 1.5"X5.2"X6.0" |
| 13.2.2* | Antenna | | | | X | v_*13.2.2 | Using a ruler, make sure the antenna of the system does not exceed 4". |

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| 13.2.2.1* | Antenna | | | | X | v_13.2.2.1 | Visually inspect that the system has the internal antenna installed. |
| 14.1 | Telezapper | X | | | | v_14.1 | Test laptop will simulate computer generated calls and the system should detect those calls. |
| 14.2 | Telezapper | X | | | | v_14.2 | Test laptop will simulate computer generated calls and the system should drop those calls after detecting them. |
| 14.3 | Telezapper | X | | | | v_14.3 | Test laptop will simulate computer generated calls and the system should erase its programmed number from the test laptop's database. |
| 15.1.1 | Vision Impaired | | | | X | v_15.1.1 | Visually inspect that the system has Braille system installed. |
| 15.1.2 | Vision Impaired | | | X | | v_15.1.2 | Operate system to verify audio status and prompts work properly. |
| 15.2.1 | Hearing Impaired | | | | X | v_15.2.1 | Visually inspect system's display and verify if system status, prompts, and caller simulated information are displayed. |
| 15.2.2 | Hearing Impaired | | | | X | v_15.2.2 | Visually inspect system's light indicators work properly. |
| 15.2.3 | Hearing Impaired | X | | | | v_15.2.3 | Test laptop will generate simulated call and the system must print out messages in the system's display. |

**Verification String Numbers (VSN)**

A Verification String Number (VSN) combines the requirement with corresponding verification numbers and requirements.

VSN 1: Ensures that the system is secure.

- Test 8.1: Plug secure access diagnostic program from test laptop. Several case data will be inputted into the system.
- Test 8.1.1: Test Laptop exposes system to a predetermine number of passwords.
- Test 8.1.2: Test Laptop will provide multiple valid passwords.
- Test 8.1.3: System shall authenticate the valid passwords and display a failure message or menu options depending on authentication.
- Demonstration 8.2: Operate system and verify the integrity of the recorded message after the system settings have been modified and after power has been discontinued for 5 min. Test 1 in 1000 units

VSN 2: Ensures connectivity between the system and a telephone and power systems.

- Examination 1.1: See whether system has connection. System fails if there is no connection.
- Test 1.1: User plugs AC adapter into connector. System fails if the AC adapter does not connect.
- Test 1.3: Remove batteries and plug AC/DC adapter into a working electrical outlet. System fails if the system does not fully operate.
- Test 4.1: Randomly select two cordless and two corded telephones that meet FCC regulations. Connect the system to each telephone. System fails if the system does not fully function or if the telephone does not operate while connected to the system.
- Demonstration 4.2: User plugs cables into connection and routs them into the channel. System fails if the cables do not fit into channels or it is too difficult of a task to complete.

- Examination 4.2: See whether there is a continuous molded channel. System fails if channel is not continuous.
- Test 4.3: Plugs cables into both jacks. System fails if the cables do not connect.
- Examination 4.3: See whether there are two jacks. System fails if two jacks are not present.

VSN 3: Ensures that the back up method becomes activated when power is not available and works properly without a degradation in function or performance.

- Demonstration 1.2: : User places uncharged batteries in system and unplugs the system after six hours. System fails if the system does not fully operate after being unplugged.
- Examination 1.2: See whether the system contains batteries. System fails if there are no batteries.
- Demonstration 1.4: User unplugs AC/DC adapter from fully charged system. System fails if the system does not operate fully for 36 consecutive hours.

VSN 4: Tests components and subsystems associated with the recording process and/or providing additional call information.

- Analysis 5.1: Record pitch and measure decibels while message is being recorded. Record pitch and measure decibels while the recorded message is being played back. System fails if the delta between the measurements exceeds 10%.
- Demonstration 5.1: Message is recorded into the system and played back to a sample size of ten users of varying ages and hearing abilities, which are representative of the user population. The sample must record what they heard on the message. System fails if any member of the sample is not able to correctly repeat the recorded message.
- Test 5.1: Connect sound module to a sin wave generator and measure the amplitude of signal in oscilloscope. Any distortion of more than 10% will account as component failure.
- Test 6.2: Plug microphone component into test laptop containing voice wave samples. The amplification of the voice wave should be at least 1.5 times the signal at entry.
- Demonstration 6.2: Factory demonstration should include testing microphone option of every 1 in 1,000 machines.
- Demonstration 10.1: Operate system and use stop watch to time the recording time limits of at least 1 in 1000 units.
- Test 11.3: Set test laptop to subject the system into different simulated call times. The system should reflect the correct date and time the message was left.
- Demonstration 11.3: Factory demonstration will do sample testing on batch lots to test the system's data stamp function. 30 out of a 1000 failures generate a batch lot failure.

VSN 5: Inspects whether or not components on the user interface are both included and working properly.

- Test 3.1: Instruct user to select interface for each function designated. System fails if it takes the user longer than 1 minute to correctly identify interface.

- Examination 3.1: Visually inspect that there is an interface for all functions with a connection to the appropriate circuit. System fails if this does not exist.
- Demonstration 3.2: The user initiates the memo function and follows the prompts to record a memo. The system fails if the user cannot determine how to activate the memo function and/or cannot understand the promptings to successfully record a memo.
- Examination 3.2: Visually inspect that there is an interface with a connection to the appropriate circuits. System fails if this does not exist.
- Test 3.3: Instruct the user to perform a task, and with a stopwatch, measure the time that it takes to complete the task. System fails if this time is greater than 2 minutes for each task.
- Examination 3.3: Visually inspect that there is a unique interface for each function that is clearly labeled. System fails if this does not exist.
- Analysis 3.4: Collect sample of pointer finger diameters. Compare the diameter distribution the minimum combined spacing plus interface size. System fails if the finger diameter at 95% is greater than the minimum combination of spacing plus interface.
- Examination 3.4: Measure the spacing between all inputs devices. System fails if the spacing is less than 2 cm.
- Examination 7.2: Visually inspect that all indicators are easily identifiable.
- Examination 7.2.1: Visually inspect that recoded message indicator displays the right number of messages and lights-up.
- Examination 7.2.2: Visually inspect that all buttons light-up.
- Examination 7.3: Plug LCD display to test laptop and run font test. All signals must be display in 14 pt. Font.
- Test 9.1: Plug remote access diagnostic program from test laptop. Several case data will be inputted into the system. Predefined failures and successes will be recorded
- Examination 11.1: Visually inspect the system's multi-digit display. The system should have all the light indicators working properly and must show the correct number of newly recorded messages.
- Test 11.2: Plug the system's LCD/digital display to a test laptop and run several call scenarios. Make sure the system reflects the right scenario (caller) information.
- Examination 11.2: Visually inspect the system's LCD or digital display. System failure occurs if the display fails to reflect test information on its screen.
- Examination 12.2: Visually inspect the system's LED indicators. The system should have all the light indicators working properly and must show the correct number of newly recorded messages.
- Examination 15.1.1: Visually inspect that the system has Braille system installed.
- Demonstration 15.1.2: Operate system to verify audio status and prompts work properly.
- Demonstration 10.3: Select Mailbox 1 and make sure that Mailbox 1’s messages are played. Select a different mailbox and make sure that the messages for the other mailbox are played.

- Examination 15.2.1: Visually inspect system's display and verify if system status, prompts, and caller simulated information are displayed.
- Examination 15.2.2: Visually inspect system's light indicators work properly.
- Test 15.2.3: Test laptop will generate simulated call and the system must print out messages in the system's display.

VSN 6: Tests components and subsystems associated with the Telezapper function.

- Test 14.1: Test laptop will simulate computer generated calls and the system should detect those calls.
- Test 14.2: Test laptop will simulate computer generated calls and the system should drop those calls after detecting them.
- Test 14.3: Test laptop will simulate computer generated calls and the system should erase its programmed number from the test laptop's database.

VSN 7: Ensures that the initial settings to operate can be executed by the user.

- Demonstration 2.1: User selects menu option to record message. User speaks into the microphone. The system converts sound waves into digital components. System fails if the system does not successfully complete the following: prompt user to record the message, covert sound into digital components, record complete message accurately, or play new message at the next outside phone call.
- Demonstration 2.2: User selects menu option to select the number of rings. The system accepts the input and adjusts the number of rings setting. After receiving an outside phone call, the system picks up after the new set number of tings. System fails if the system does not prompt the user to change the number of rings, adjust the settings for the input, or intercept an outside phone call after the set number of rings.
- Test 7.1: Plug speaker component into test laptop containing voice recording diagnostic program. Different volume options have been pre-selected. wave samples.
- Demonstration 7.1: Factory demonstration should include testing volume adjustability option of every 1 in 1,000 machines.
- Demonstration 10.2: Operate system and use stop watch to time the greeting recording time limit of at least 1 in 1000 units.
- Test 12.1: Set test laptop to play with the different settings of the system. The system should reflect the test laptop's request.
- Demonstration 12.1: Factory demonstration will do sample testing on batch lots to test current settings of the system. 3% failure of the lot generates a lot failure.

VSN 8: Examines whether the system can be properly stored given indented space constraints.

- Examination 13.1.1: Using a weight scale, make sure the system's weight does not exceed 16 oz.
- Examination 13.2.1: Using a ruler, make sure the system's dimension and size don't exceed 1.5"X5.2"X6.0".

- Examination 13.2.2: Using a ruler, make sure the antenna of the system does not exceed 4".
- Examination 13.2.2.1: Visually inspect that the system has the internal antenna installed.

**Verification Plan**

The Verification Plan, which is shown in Table 8, puts the verification methods into sequence to create an executable plan for ensuring that the requirements have been met. The verification methods that are used to verify that the architectural driver requirements have been made are separated from the product-specific requirements.
The unique plan for a platform would be composed of the Verification Plan for architectural drivers and applicable requirement verification methods from the platform-specific verification plan. Separating the verification methods for architectural drivers takes advantage of benefits, such as learning, due to the common processes.

Developing two separate Verification Plans for architectural drivers and product-specific requirements promotes reuse. A new product could reuse the Verification Plan for the architectural drivers and benefit from lessons learned and a developed plan. New additional requirements that are specific to the new product could be included in the product-specific test plan. This should ultimately save time and money, which would result in creating successful products fast and for less money.

Table 8: Verification Plan

| Task | Verification Paragraph | Method | Architectural Driver Requirements Verification Method Description |
|---|---|---|---|
| 1 | v_4.3 | T | Plugs cables into both jacks. System fails if the cables do not connect. |
| 2 | v_7.3 | T | Plug LCD display to test laptop and run font test. All signals must be display in 14 pt. Font. |
| 3 | v_6.2 | T | Plug microphone component into test laptop containing voice wave samples. The amplification of the voice wave should be at least 1.5 times the signal at entry. |
| 4 | v_1.1 | T | User plugs AC adapter into connector. System fails if the AC adapter does not connect. |
| 5 | v_1.3 | T | Remove batteries and plug AC/DC adapter into a working electrical outlet. System fails if the system does not fully operate. |
| 6 | v_3.1 | T | Instruct user to select interface for each function designated. System fails if it takes the user longer than 1 minute to correctly identify interface. |
| 7 | v_3.3 | T | Instruct the user to perform a task, and with a stopwatch, measure the time that it takes to complete the task. System fails if this time is greater than 2 minutes for each task. |
| 8 | v_5.1 | T | Connect sound module to a sin wave generator and measure the amplitude of signal in oscilloscope. Any distortion of more than 10% will account as component failure. |
| 9 | v_7.1 | T | Plug speaker component into test laptop containing voice recording diagnostic program. Different volume options have been pre-selected wave samples. |

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| 10 | v_8.1 | T | Plug secure access diagnostic program from test laptop. Several case data will be inputted into the system. |
| 11 | v_11.3 | T | Set test laptop to subject the system into different simulated call times. The system should reflect the correct date and time the message was left. |
| 12 | v_12.1 | T | Set test laptop to play with the different settings of the system. The system should reflect the test laptop's request. |
| 13 | v_5.1 | A | Record pitch and measure decibels while message is being recorded. Record pitch and measure decibels while the recorded message is being played back. System fails if the delta between the measurements exceeds 10%. |
| 14 | v_6.2 | D | Factory demonstration should include testing microphone option of every 1 in 1,000 machines. |
| 15 | v_7.1 | D | Factory demonstration should include testing volume adjustability option of every 1 in 1,000 machines. |
| 16 | v_11.3 | D | Factory demonstration will do sample testing on batch lots to test the system's data stamp function. 30 out of a 1000 failures generate a batch lot failure. |
| 17 | v_12.1 | D | Factory demonstration will do sample testing on batch lots to test current settings of the system. 3% failure of the lot generates a lot failure. |
| 18 | v_2.1 | D | User selects menu option to record message. User speaks into the microphone. The system converts sound waves into digital components. System fails if the system does not successfully complete the following: prompt user to record the message, covert sound into digital components, record complete message accurately, or play new message at the next outside phone call. |
| 19 | v_4.2 | D | User plugs cables into connection and routs them into the channel. System fails if the cables do not fit into channels or it is too difficult of a task to complete. |
| 20 | v_5.1 | D | Message is recorded into the system and played back to a sample size of ten users of varying ages and hearing abilities, which are representative of the user population. The sample must record what they heard on the message. System fails if any member of the sample is not able to correctly repeat the recorded message. |
| 21 | v_8.2 | D | Operate system and verify the integrity of the recorded message after the system settings have been modified and after power has been discontinued for 5 min. Test 1 in 1000 units |
| 22 | v_10.1 | D | Operate system and use stop watch to time the recording time limits of at least 1 in 1000 units. |
| 23 | v_10.2 | D | Operate system and use stop watch to time the greeting recording time limit of at least 1 in 1000 units. |
| 24 | v_13.1.1 | E | Using a weight scale, make sure the system's weight does not exceed 16 oz. |
| 25 | v_13.2.1 | E | Using a ruler, make sure the system's dimension and size don't exceed 1.5"X5.2"X6.0" |
| 26 | v_13.2.2 | E | Using a ruler, make sure the antenna of the system does not exceed 4". |
| 27 | v_13.2.2.1 | E | Visually inspect that the system has the internal antenna installed. |
| 28 | v_4.2 | E | See whether there is a continuous molded channel. System fails if channel is not continuous. |
| 29 | v_1.1 | E | See whether system has connection. System fails if there is no connection. |
| 30 | v_4.3 | E | See whether there are two jacks. System fails if two jacks are not present. |
| 31 | v_3.1 | E | Visually inspect that there is an interface for all functions with a connection to the appropriate circuit. System fails if this does not exist. |
| 32 | v_3.3 | E | Visually inspect that there is a unique interface for each function that is clearly labeled. System fails if this does not exist. |

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| 33 | v_7.2 | E | Visually inspect that all indicators are easily identifiable. |
| 34 | v_12.2 | E | Visually inspect the system's LED indicators. The system should have all the light indicators working properly and must show the correct number of newly recorded messages. |
| 35 | v_7.2.1 | E | Visually inspect that recoded message indicator displays the right number of messages and lights-up. |

| Task | Verification Paragraph | Method | Platform-specific Requirements Verification Method Description |
|---|---|---|---|
| 1 | v_6.1 | T | Plug memory chip into test laptop containing voice wave samples. Chip must record voice wave with a minimum of 24 db (whisper). |
| 2 | v_14.1 | T | Test laptop will simulate computer generated calls and the system should detect those calls. |
| 3 | v_14.2 | T | Test laptop will simulate computer generated calls and the system should drop those calls after detecting them. |
| 4 | v_11.2 | T | Plug the system's LCD/digital display to a test laptop and run several call scenarios. Make sure the system reflects the right scenario (caller) information. |
| 5 | v_15.2.3 | T | Test laptop will generate simulated call and the system must print out messages in the system's display. |
| 6 | v_14.3 | T | Test laptop will simulate computer generated calls and the system should erase its programmed number from the test laptop's database. |
| 7 | v_8.1.1 | T | Test Laptop exposes system to a predetermine number of passwords. |
| 8 | v_8.1.2 | T | Test Laptop will provide multiple valid passwords. |
| 9 | v_8.1.3 | T | System shall authenticate the valid passwords and display a failure message or menu options depending on authentication. |
| 10 | v_9.1 | T | Plug remote access diagnostic program from test laptop. Several case data will be inputted into the system. Predefined failures and successes will be recorded |
| 11 | v_4.1 | T | Randomly select two cordless and two corded telephones that meet FCC regulations. Connect the system to each telephone. System fails if the system does not fully function or if the telephone does not operate while connected to the system. |
| 12 | v_3.4 | A | Collect sample of pointer finger diameters. Compare the diameter distribution the minimum combined spacing plus interface size. System fails if the finger diameter at 95% is greater than the minimum combination of spacing plus interface. |
| 13 | v_6.1 | D | Factory demonstration should include testing the memo recording option of every 1 in 1,000 machines. |
| 14 | v_1.4 | D | User unplugs AC/DC adapter from fully charged system. System fails if the system does not operate fully for 36 consecutive hours. |
| 15 | v_1.2 | D | User places uncharged batteries in system and unplugs the system after six hours. System fails if the system does not fully operate after being unplugged. |
| 16 | v_2.2 | D | User selects menu option to select the number of rings. The system accepts the input and adjusts the number of rings setting. After receiving an outside phone call, the system picks up after the new set number of tings. System fails if the system does not prompt the user to change the number of rings, adjust the settings for the input, or intercept an outside phone call after the set number of rings. |

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| 17 | v_3.2 | D | The user initiates the memo function and follows the prompts to record a memo. The system fails if the user cannot determine how to activate the memo function and/or cannot understand the promptings to successfully record a memo. |
| 18 | v_15.1.2 | D | Operate system to verify audio status and prompts work properly. |
| 19 | V_10.3 | D | Select Mailbox 1 and make sure that Mailbox 1's messages are played. Select a different mailbox and make sure that the messages for the other mailbox are played. |
| 20 | v_3.2 | E | Visually inspect that there is an interface with a connection to the appropriate circuits. System fails if this does not exist. |
| 21 | v_1.2 | E | See whether the system contains batteries. System fails if there are no batteries. |
| 22 | v_3.4 | E | Measure the spacing between all inputs devices. System fails if the spacing is less than 2 cm. |
| 23 | v_7.2.2 | E | Visually inspect that all buttons light-up. |
| 24 | v_15.2.2 | E | Visually inspect system's light indicators work properly. |
| 25 | v_11.1 | E | Visually inspect the system's multi-digit display. The system should have all the light indicators working properly and must show the correct number of newly recorded messages. |
| 26 | v_11.2 | E | Visually inspect the system's LCD or digital display. System failure occurs if the display fails to reflect test information on its screen. |
| 27 | v_15.1.1 | E | Visually inspect that the system has Braille system installed. |
| 28 | v_15.2.1 | E | Visually inspect system's display and verify if system status, prompts, and caller simulated information are displayed. |

## Coverage and Completeness

After developing the Verification Plan, it is important to verify that all high-level requirements will be verified through execution of the plan. The High-level Requirements Traceability Matrix, which is shown in Table 9, maps the verification methods with each high-level requirement. This ensures that the Verification Plan does provide verification methods for all high-level requirements and can, therefore, be considered complete.

Table 9: High-level Requirements Traceability Matrix

| Req. # | Requirement Description | Verification Method | | | |
|---|---|---|---|---|---|
| | | T | A | D | E |
| 1 | The system shall record and maintain messages at all times. | 1.1 thru 1.3 | | 1.2 & 1.4 | 1.1 & 1.2 |
| 2 | The system shall allow user to personalize outgoing message and settings. | | | 2.1 & 2.2 | |
| 3 | The system's interface shall be easy to use. | 3.1 & 3.3 | 3.4 | 3.2 | 3.1 thru 3.4 |
| 4 | The system must interface with a standard telephone. | 4.1 & 4.3 | | 4.2 | 4.2 & 4.3 |
| 5 | The system shall record messages accurately. | | 5.1 | 5.1 | |
| 6 | The system should record messages internally (not through the phone). | 6.1 & 6.2 | | 6.1 & 6.2 | |

| | | | | | |
|---|---|---|---|---|---|
| 7 | The system shall play recorded messages clearly and audibly. | 7.1 & 7.3 | | 7.1 | 7.2, 7.2.1 & 7.2.2 |
| 8 | The system shall store recorded messages securely. | 8.1 & 8.1.1 thru 8.1.3 | | 8.2 | |
| 9 | The system should be accessible remotely. | 9.1 | | | |
| 10 | The system shall have an adequate amount of recording capacity. | | | 10.1 - 10.3 | |
| 11 | The system should provide calling information in addition to recorded message. | 11.2 & 11.3 | | 11.3 | 11.1 |
| 12 | The system shall indicate the status of recorded messages. | 12.1 | | 12.1 | 12.2 |
| 13 | The system shall be a manageable size to store. | | | | 13.1.1, 13.2.1, 13.2.2 & 13.2.2.1 |
| 14 | The system should be able to eliminate telemarketers. | 14.1 thru 14.3 | | | |
| 15 | The system should be usable by vision or hearing impaired user. | 15.2.3 | | 15.1.2 | 15.1.1, 15.2.1 & 15.2.2 |

## 9. Conclusion

As previously mentioned, Platform based design is gaining grounds in the manufacturing of commercial products because it has shorten the design and development process times. Beyond the benefits of reduced time to market, decreased development and production costs, platform design lends itself to the application of current industrial quality methodologies like Six Sigma, Supply Chain Management, Total Quality Management and Reengineering. The prime driver to platform design is to: “Achieve mass customization to satisfy individual customer needs while striving for mass production efficiency (Pine II)”. The mass production aspect of platform design of a commercial product allows for not for reuse due to component communality, but for process and test reuse as well.

This project has described a Platform Design for a commercial answering machine. By grouping the project into layers characterized by levels of abstraction design complexity has been kept at check, while customer requirements were extended to lower level requirements and were eventually captured into distinctive design features in the different product variants. The V&V plan stretches to all aspects of the design process and connects requirements, verification methods, verification requirements, and levels of application in a matrix format for better visualization.

By using the approached defined in this document, the design effort of a single product resulted in the creation of five (5) distinct products (product variants). The platform being a high sound quality answering machine and the variants included: Low-end (high

quality answering machine), medium (phone and 3 inboxes), high (phone and 5 inboxes), TTY text and Braille models.

## 10. Future Work

The need to stay connected is paramount in today's society. We are living and breathing in the Communication Revolution Era, where the only constant is change. Judging by the advances in communication, specifically voice and data package transmittal over high-speed Internet, it seems that the next generation of answering machines will be message routers. These routers could be connected to all communication devices available to the user like TV, satellite radio, PDA, email, cellular, and home telephone. The key goal is to have the message reach the intended recipient as fast as possible. Of course the user would be given the option to transfer the message to whichever device(s) he or she prefers (see Figure 8).

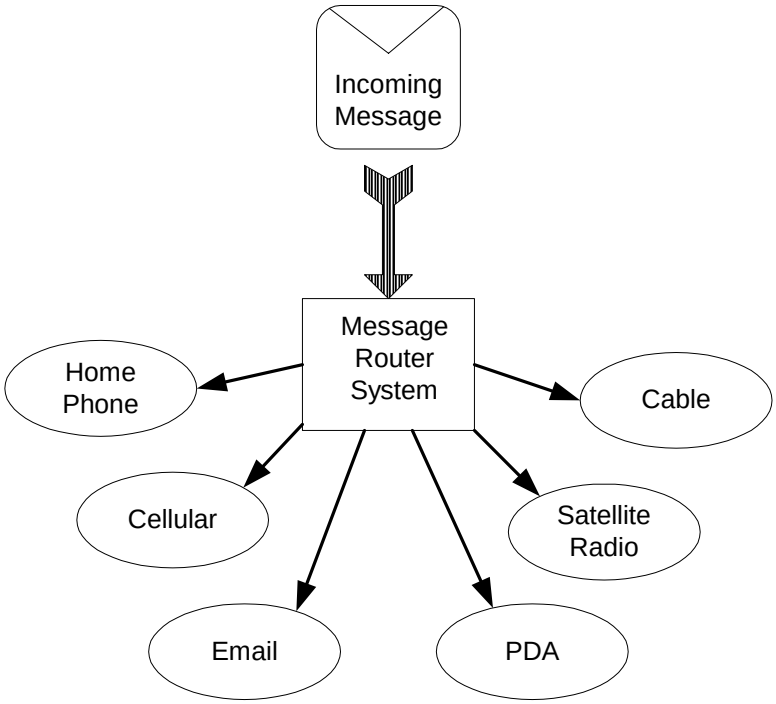


Figure 8: Answering Machine as Message Router

Changes in regulation are trailing behind technology changes. The US Federal Communications Commission (FCC) just recognized on February 12 of 2004 that the Internet-based VoIP was an unregulated information service and embarked in a task to determine FCC's role with respect to this communication option. Figure 9 includes an overview of how VoIP operates. In November 9, 2004 the FCC decided that VoIP services are of interstate nature. VoIP related services will undergo analysis and a complete report is expected in spring of 2005. A heated battle will likely ensue between the traditional telephone companies and VoIP providers, due to the apparent regulatory advantage of VoIP over the conventional telephone companies, which are state regulated.

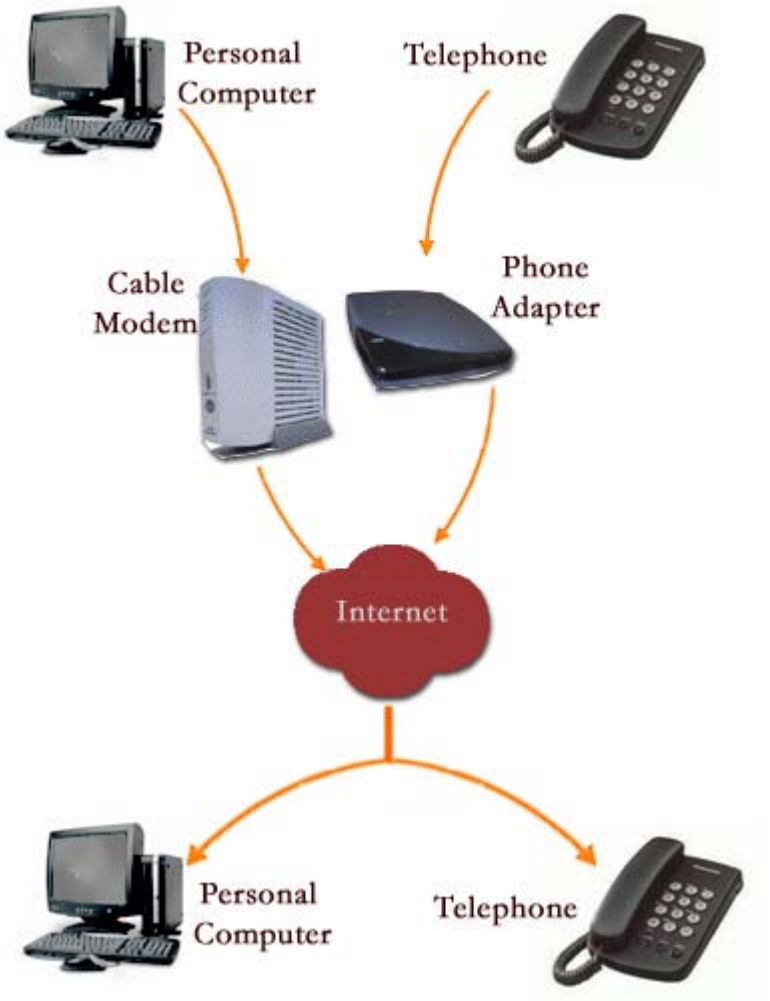


Figure 9: VoIP Home network Option
(obtained from FCC website www.fcc.gov/voip)

Our vision of the future is that people will have constant interaction with an information infrastructure in their everyday lives thru devices much like cell phones. All marketing will be customized to a virtual user profile stored in a Federal database. Vendors will be allowed to extract information, which the user would have chosen to release about his/her interests. For instance a cell phone could download music files of specific appeal to the user and play them thru the user's cell phone while he/she shops for groceries. Or a virtual coupon database could automatically download manufacturer discount coupons to his/her cell phone for items that the user has purchased in the past as the user enters a store. Networks would be able to talk to each other, while providing seamless coverage to the user.

However for this future to be possible companies must invest in the present to bust consumer confidence and to eradicate all glitches from their networks, like drop calls. In

addition, security measures will have to be investigated and will amount to a considerable investment for private industry; therefore, partnerships between organizations like Universities, FCC, Homeland Security Administration and private industry are likely to develop to carry the financial load of technology advancement.

Wireless communication providers are already investigating ways to increase and optimize coverage in suburban areas, with the goal to remove the need to have a permanent home line. The user arrives home and it just needs to lay down his/her cell phone on the home phone base and all home cordless units connect to the cellular number (see Figure 10).

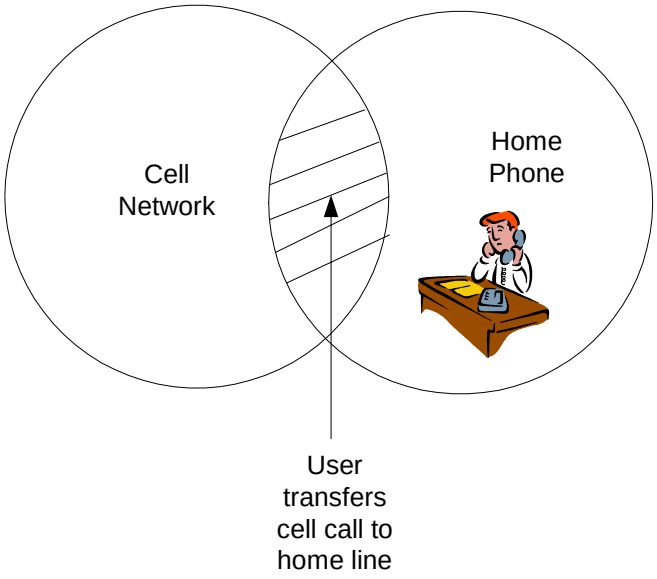


Figure 10: No Need For Separate Home Line

These technology advances will generate the need for all sort of commercial products, and platform design methodologies as well as new Systems Engineering applications will provide the advantage required for capturing the market. Stay tuned.

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  http://www.pcs.com/
  TTY – Telephones for the Deft and Speech Impaired: Arizona Hearing Online.
  http://azhearing.com/tty/Default.htm
  Voice Over Internet Protocol Facts, Federal Communications Commission.
  http://www.fcc.gov/voip/