Feature Interactions in VoIP Networks

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Abstract-Internet Telephony provides telephone-like services over the Internet. Call features are functions of communication equipment, which provide some sort of service to its service subscribers, for example, call waiting, call forwarding, and three-way calling. As the number of call features grows, the interference which we call feature interaction, among features increases.

Feature interaction exists in traditional PSTN (Public Switched Telephone Network). Lots of effort and money have been spent to identify and prevent them by equipment providers. But still no satisfactory method exists. As the growth of internet continues and the bandwidth of internet increases, a lot more services of internet telephony will be available and the feature interaction problem will become more serious than the traditional PSTN.

Aiming at the getting popular internet telephony, this paper focuses on the investigation of identification of feature interactions and methods for preventing them.

Keywords—Call Features, Feature Interaction, VoIP, PSTN, Communication Networks

I. INTRODUCTION

Internet Telephony provides telephone-like services over the Internet. As telecommunication technology evolves, new technology like voice over IP (VoIP) has begun to pick up in the telephony market. VoIP or more accurately, media over IP, has gained lots of acceptance in the world. Companies like Skype, Vonage, net2phone, and even Internet portals have created a huge market in Internet telephony. As the growth of the Internet continues and the bandwidth of Internet increases, Internet telephony will become an integrated service of any media and have a greater impact on our daily life.

Internet telephony services are termed as call features by the “old” communication equipment manufacturers. In fact, call features are functions of communication equipment, which provides some sort of services to its service subscribers. Some common call features are call waiting, call forwarding, and caller ID. As more new services are requested by customers, service providers have to provide more features to serve subscribers. As the number of call features grows, a phenomenon called feature interaction occurs. Feature interactions are caused by interference from various call features, and they cause the call features to act unexpectedly or improperly because of the interference. Some examples of feature interactions are described below:

Example1. Consider two features “Call Waiting” (CW) and “Call Forwarding When Busy” (CFB). CW allows a subscriber to switch to another incoming call when talking to someone and eventually switch back to the original call. CFB will forward the incoming call to a specified number when the phone is busy. Suppose a subscriber subscribes to these two features and is engaging in a call. When a new call arrives, there will be interference and therefore an interaction between these two features, i.e., would this new call be forwarded to another number or would the subscriber receive an alert tone for call waiting?

Example2. A subscriber with the “Call Forwarding” feature (CF) can redirect his calls to other phone numbers. A “looping” condition can occur in some situations, e.g., the subscriber accidentally redirects the call back to his own number. Sometimes, the loop can involve more than one person, e.g., subscriber A redirects his call to subscriber B, and subscriber B redirects his call to subscriber A. The looping condition is difficult to detect during the calling processing. A kluge can be installed in the signaling system to relieve this problem.

The feature interaction problem is not limited to the examples described above. Even with Public Switched Telephone Networks (PSTN) in the old days, which already had more than one thousand calling features that had been developed by the telecommunication equipment providers, feature interactions among the numerous call features was known to occur.

Many approaches have been proposed to solve this problem. Unfortunately, as the number of features increases, the complexity of solving this problem also increases. Whenever a new developed feature is added to the existing feature set, a very complicated process/algorithm needs to be performed to first detect the feature interaction and then an effort has to be spent to resolve the issue. As a matter of fact, the cost of developing a new feature is similar to that of solving the introduced feature interaction problem.

Internet telephony technology, reduces some of feature interaction problems, but at the same time introduces some new feature interactions. Consider the following example:

Example3. Let’s consider the interaction between “Outgoing Call Screening” (OCS) and “Call Forwarding” (CF). OCS blocks calls made to certain destinations. Assume X is one of the destinations to be blocked and Y is some location where the CF to X has been activated. Now a call to Y can be forwarded to X even if it is supposed to be blocked. This scenario can also occur in PSTN, but Internet telephony will worsen the interaction since in Internet telephony, the
destination can be easily hidden by changing the destination address.

This paper investigates the feature interaction problem in the Internet telephony area and finds a new and easy to adopt method to prevent future feature interactions.

II. RELATED RESEARCH

Until today, most of the research in the feature interaction area has been to address issues in PSTN area. There is not much research to be found which deals with Internet telephony. We summarize below the research in PSTN.

The research in this area mainly concentrates on two directions. The first is to identify various types of feature interactions. The second proposes methods to avoid them. In [1], there is a summary about the types of feature interactions and existing approaches to prevent them. Based on [1], the types of feature interactions can be divided into five categories.

- **Single-User-Single-Component (SUSC) Interactions**
  SUSC interactions occur because incompatible features are simultaneously used by a single user in a single network component, such as a switching system or a service control point (SCP). Some of these interactions arise because of functional ambiguities, i.e., two different features are designed to deal with the same call-processing situation, but differ as to how it will be handled. Some are caused by interferences, i.e., one feature will preclude the proper execution of another feature. Others may arise due to resource/signaling limitation.

- **Single-User-Multiple-Component (SUMC) Interactions**
  When features accessible to one customer are deployed in different network components, interactions may occur if the existence of one feature is not known to or has not been considered by the designers of features in other network components.

- **Multiple-User-Single-Component (MUSC) Interactions**
  Interactions occur when two or more customers access the features associated with a physical line. Personal Communication Services (PCS)’s dynamic binding of subscribers to CPEs introduces this type of interaction.

- **Multiple-User-Multiple-Component (MUMC) Interactions**
  Interactions occur when two or more users access features supported on multiple network components.

- **Customer-System (CUSY) Interactions**
  Interactions arise when user features interact with any system feature in operating, administrating, maintaining, and provisioning.

Some of the interactions described above can be easily resolved by negotiation and policy change. Some can be resolved at the feature design time by following common agreed standards. Others may still require more in-depth investigation. Existing methods to manage feature interaction problems can be divided into three categories.

- **Infrastructures for Deployment**
  This set of approaches tries to create a more friendly deployment environment by using, for example, a richer set of functional signals which could help resolve some ambiguities caused by limited CPE signaling capabilities. Another example would be using both standardized APIs and a carefully designed interface protocol. This is useful to address communication needs and interoperability issues among network components.

- **Design Support**
  This group of methods typically concentrates on the early detection of interactions during the design phase. Some interactions can be detected easily by checking the assumptions of a feature against properties of the environment in which the feature will be deployed. Others, such as the interactions caused by timing and race conditions, may require sophisticated formal techniques for specification and reasoning.

- **Run-time Resolution**
  Because of the diverse preferences of customers, no single policy could be satisfactory, nor could precedent exist for resolving conflicting call control. Therefore, a run-time resolution, which could be adjusted to the satisfaction of most of customers, is another solution.

III. FEATURE INTERACTION IDENTIFICATION AND PREVENTION

A. General Considerations

Two factors to keep in mind when searching for the solutions of feature interactions are performance and implementation. For telecommunication equipment manufacturers, a measurement of the superiority of equipment is the performance of call processing in terms of number of calls per second. If the solution causes the call processing rate to go down, it definitely won’t be used. If the solution can sustain the call processing rate, yet another issue to consider is the effort needed to implement the solution. It does not make sense for a manufacturer to implement an expensive solution.

Different from the results of [1], we find real causes of feature interactions. In [1], the categories of feature interactions are identified, but the names of the interactions do not show the causes and the names are just a “phenomenal” classification. There are lots of different causes for feature interactions. We categorize these causes and then concentrate on each category to find solutions for each group. We also investigate a possibility to find a general solution for any feature interaction problem.

B. Identification of Feature Interactions

The approach we take to find feature interactions is to go deep into features themselves. A feature basically is a set of controlled reactions to the control signals or messages. Whenever a control signal coming in, the feature control has to decide which action should be taken. If there is no control signal, the feature control does nothing.
Using this analysis, we claim that to identify feature interactions, the best way to do is to analyze the control signals associated with features. If two features receive the same control signals there is a possibility that a feature interaction could occur.

Of course, receiving same control signals is not necessarily the real reason to cause the feature interaction. Some other factors might also apply. For example, if two features receive the same control signal at different time frames then there is no way that these signals will cause any interaction. Thus, timing is another factor which contributes to the feature interaction. However, we believe that timing issue is only presented when two control signals occur at the same time.

While talking about control signals, one issue arises - the source of the signals. As we investigate the interaction problem in Internet telephony, the major difference from the traditional PSTN is the controlled environment. In the traditional PSTN environment, equipments and links are under very tight control. That is, they are placed inside service provider’s equipment offices and only authorized personnel can have access to them. Also, the feature control is provided by the equipment manufacturers. The feature control remains unchanged until the next time when system upgrade is to be done. The possibility that an intruder can get in to change the feature control is rare if not impossible. On the other hand, in the internet telephony environment, the call control could exist on any equipment (most of them PCs), e.g., the end-point PCs, which makes and receives phone calls. These equipments are very easy to access and users can add some program logics as they want. This in turns introduces some unrelated control signals and they might also contribute to the feature interaction.

As a summary, to identify feature interactions, we have focused on the feature’s control signals and put attentions on their sources and timing.

C. Feature Interaction Prevention

As stated above, feature interactions could be caused by different reasons. To prevent them, therefore, we need to take different factors into account.

The first thing we address is the precedence of various features. Different subscribers might prefer different precedence of features. Thus, the feature requirements on the order of feature execution have to be very clear and accurate. Based on the order of features specified in the requirement, the feature execution can be serialized as in the database transaction.

The second issue following from the first is how to serialize the features. One important item to consider is the granularity of the serialization. If we serialize the features based on calls, subscribers would then lose lots of calls or get long delay between calls. Our approach is to control at the signaling/message level. That is, when there is a signaling event occurring, the order of reactions to that event from several features will be based on the precedence specified in the feature requirement. This level selection coincides with our analysis in the above section.

By serializing feature reactions to the control signals has another advantage. With the signal carrying the originator information, some of interactions caused by non-call-processing related signals also can be prevented.

As a summary, we choose to create a run-time control mechanism which can avoid or resolve feature interactions by serializing the feature reactions to the control signal. The run-time approach is self-contained. It does not have any restriction on the developing of applications on any equipment in the network.

D. Future Research

At this stage, we have identified two problems that would occur during our research.

A) Interactions from Security Issues in the Internet

Security problems in the Internet could cause some feature interactions. These security problems definitely will impact the Internet telephony services by interfering with the features. It is difficult to totally eliminate the attacks from the Internet. We plan to have another research proposal to deal with it.

B) Interactions with PSTN Networks

When considering the interaction problems arising from the Internet, It is possible that a call might be originated from a PSTN network and terminated in the Internet or vise versa. At this point, we think that as long as the signaling gateway functions properly, the combination of two different types of network should not introduce new problems.

IV. CONCLUSION

We have analyzed causes of different types of feature interaction in a VoIP environment and proposed solutions to prevent them. As VoIP becomes popular, more and more call features will be developed. This paper surely provides a way to simplify the feature development process and also to reduce the development cost. This, in turn, will introduce more applications to be added to the Internet. Economically, the contribution is tremendous.

The feature interaction problem is also a problem in software development. Software interaction was found a long time ago. There is no special attention being paid on this field due to the complexity of the problem. We believe that the results of this paper would shed some light on the software interaction area and trigger more interests in that area.

REFERENCES


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