Easy Recovery Through Environment Awareness

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Summary
Recovery is the action of getting back or regaining to former status. This action involves in obtaining usable resources that are available. Thus, having awareness of the computing system's operating environment is useful either as to identify factor that can affect the system or to seek out alternative resources available in the environment. This paper presents the implementation of environment awareness in computing systems, with emphasis on facilitating user recovery from service failure by taking benefit of information from the environment where the systems operate. The discussion is illustrated with a prototype developed.
Key words:
recovery, environment awareness.

1. Introduction

Recovery from service failure is the action of getting back or regaining to previous status. Service failure may arise from various sources, such as human error and hardware faults. Error recovery and exception handling are examples of recovery techniques in fault tolerant systems [1-4], in which the systems able to continue operating in the presence of faults. Robust computer systems become more crucial in today's computing systems environment, hence, in recent years, work on automated recovery or self-recovery in computing systems has evolved dramatically. However, although many efforts have been put forward, it does not guarantee that there will be no service failures. Therefore, some kind of assistance must be offered to user to ensure continuity of service [5].

It is essential for a computing system to be able to provide a continuous service to users under almost any operating conditions. If faults are not handled properly, the system may completely fail or services provided by the system may be affected. Wherein, even a temporary service failure may cause substantial disruption for users who depend on the service and thus lead to user dissatisfaction. Thus, it is essential for a computing system 'to be aware' of the environment where the system operates. For example, system aware that a primary network link fails and it may be possible to switch users to a secondary network connection that is available to continue the service. This example can be achieved when the computing systems have awareness of what has happen and what is available in its operating environment in order to continue the service.

While autonomic computing has concerned on self-healing for achieving robustness without human intervention [6], fault management in SHRIEK [7] is based on the view that guiding user recovery from service failures is an equally important aspect of robustness in a computing service. SHRIEK is an approach to increasing the robustness of computing systems by taking benefit of environment awareness to inform self-healing and recovery [7]. Case-based reasoning (CBR) is used to guide fault diagnosis and enable learning from experience, and rule-based reasoning to enable decision making informed by environment knowledge in fault remediation and recovery. SHRIEK trigger remedial actions and identify recovery strategies when a fault diagnosis has been reached by CBR. In most situations, faults or service failures in today's computing system can be detected automatically by the system; hence recovery strategies can be achieved without go through the fault diagnosis, and thus become the basis approach proposed in this paper.

In this paper, we present an approach for facilitating user recovery from service failures using environment awareness. The reminder of this paper is organized as follows. In Section 2, we present an overview on systems recovery and user recovery from service failures. In Section 3, we discuss on issues of environment awareness in computing systems. In Section 4, we show the implementation of environment awareness for recovery in a suitable scenario. A prototype, called *USher*, is developed that stand to benefit from environment awareness for providing appropriate action for correcting the fault and guiding user recovery from its effects. *USher* is an application for notification in a local printer network based on SHRIEK approach [7] that uses relevant information automatically obtained from available sources

in the computing environment. Finally, our conclusions are presented in Section 5.

2. User Recovery From Service Failures

Computers are a necessity in almost every organisation and the services they provide are often expected to be available 24/7. IT staff continue to play an important role in ensuring continuity of service, as even a temporary loss of service may cause significant hardship for users. For example, faulty devices must be promptly repaired or replaced to avoid delays in service delivery. Inevitably, however, there may be occasions when a fault cannot easily be diagnosed or assistance from IT staff is not immediately available to guide user recovery from service failures.

Basically, recovery might involve the process of obtaining functional substances from unusable resources. For example, recovery in fault tolerance based on the use of redundant resources in the computer systems to enable fault recovery in response to hardware or software failures [3,8,9]. It is also mentioned that an essential in a robust computing system is having the ability to assist user by identifying alternative resources that provide the same service whenever problems occur [7].

Conceptually, computing systems can be seen as a number of resources that interact directly or through shared objects. As technology of computing systems is continuing to grow, inevitably, has increased the number of elements and complexity of its infrastructure. Consequently, it is difficult to identify abnormalities that originate from the environment and to identify which elements have failed. However, on contrary, there is a potential to identify alternative resources to assist user recovery from service failures in such computing systems environment. In which, users can take benefit from readily or available information that is accessible in the computing systems environment to carry out their tasks effectively. For example, users of computing systems can be informed about the status of the current services, and about the resources relevant to their tasks to avoid problems that might occur, or at least minimise the effects of service failures.

Besides, to take corrective action might take sometimes, for example replacing toner cartridge, more frustrating if there is no toner in stock. It is typically assumed that a qualified person is available to replace the toner cartridge, that this person is aware of the problem, and that the user has time to wait for a new toner cartridge to be installed. Thus, information of available and accessible resources (e.g., nearby printer, availability of person in charge) will be able to assist user recovery from service failures.

Typically, in computing service, it is helpful for users recovery from service failures when:

- Having knowledge of who is responsible for maintenance of the service
- Being informed is he/she available
- Having knowledge of what alternative resources are available and where are they located

For example, informing users of a loss of wireless network connectivity enables them to adjust their work around this limitation. Knowing of who is responsible for maintenance of the wireless network service, and their current availability, also enables to inform the user who can be contacted to discuss the problem.

3. Awareness In Computing Systems

Awareness in the Oxford Dictionary [10] is defined as the noun of "to be aware"—conscious, not ignorant, having knowledge or being well informed.

One reason for the increasing importance of environment awareness is that today's computing systems are more exposed to unforeseen events and environmental conditions. In particular, when the number of elements and complexity of its infrastructure has increase, thus more ways that things can go wrong [11]. Therefore, computer systems should know of its environment and the context surrounding its operation, and able to act accordingly, as mentioned by Horn [6] as one of the autonomic computing behaviour. Environment awareness is also needed to build cognitive systems that understand their own goals and the goals of other systems they communicate with and able to adapt their output to suit their associate systems and the situation [11].

There are available and accessible resources in the computing environment that is considered relevant to certain computing services. However, in practice, users are aware of some form of these resources but fewer are using it, in which they do not recognise that these resources will benefit their tasks to be accomplished more effectively by using the awareness information (i.e., environment knowledge [7]). Hence, it is rely on the computer systems to seeking the information or knowledge out for the users. Therefore, computer systems should be able to provide user with knowledge – knowledge about the presence, events, and availability of services and resources relevant to the user's task.

Knowledge of available resources in the environment is able to guide user recovery from service failures [7]. Awareness of alternative resources that are available in the

environment essential for recovery to ensure continuity of service. Thus, user need to be provided with relevant knowledge in order to complete his/her task or part of a task in the presence of faults or failures.

4. Recovery Using Environment Awareness

This section first discusses the potential use of environment awareness in recovery activities. Then we present a scenario that exemplifies some of the use of environment awareness in the activities.

Environment awareness in recovery process including aware about the system's event and services, accessible and available resources relevant to the services. In which, by using the awareness information or knowledge to avoid service failures. Environment awareness also encouraging sharing knowledge of resources available in computing systems environment. Moreover, by knowing what is happening might as well help to minimise the effects of service failures in the computer system and thus help to improve the effectiveness in its services. .

The following are environment awareness to support recovery functions:
- Observing events and resources in computing systems environment
- Proactive alerting to users on current services
- Detecting faults or potential problems
- Recovering by making use of accessible and available resources in computing systems environment relevant to the service
- Automated recovery informed by awareness information

4.1 The Recovery Process

The recovery process is based on control-loop activities of an autonomic element: monitor, analyse, plan, and execute [12-13].
(i)   Monitor—the system monitors and observes the behaviour and changes of service status
(ii)   Analyse—the system analyse events
(iii) Plan—identify corrective action
(iv)   Execute—triggers corrective action and suggests possible recovery strategies

As for example, the activities responsible for recovery process in printing service system are as follows:

- Monitoring
The system monitors and observes the behaviour and changes of network printer service status. Fault that might

affect the user's service are detected. The monitoring activity also enables some problems to be predicted and corrected before causing a service failure. In addition, the system also monitors other resources in the environment that are related to the service (e.g., toner inventory, technician in charge).

- Analysing and Planning
The system analyses fault that might affect the user's service; identify technician in charge, and other available resources. Plan for corrective action, and recovery strategies. For example, replace new toner cartridge as corrective action when printer is out of toner and using other available printer for immediate recovery.

- Executing
The system triggers corrective action and suggests possible recovery strategies for effected users. For example, corrective action for the fault is informed to the user and reported to the technician in charge.

The following sections discuss a scenario used to illustrate the idea and a prototype developed that employ the recovery process for printing service.

4.2 The Scenario

The use of environment awareness in recovery activities is presented in this section. Network printing service system is use as an example for the implementation [5]. Fig. 1 illustrates the problem situation in the printing service system.

Users may sometimes experience difficulties with the service, for example in Fig. 1 when printer is out of toner or user's print job stuck in a long queue. Interruptions to the printing service may possibly prevent the user from completing an urgent task, thus causing her to feel dissatisfied and frustrated with the service.
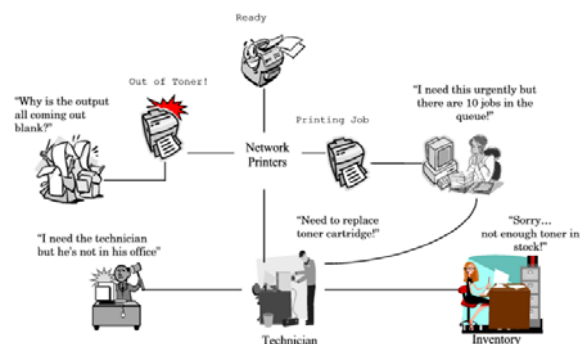

Fig. 1 Common problems in printing service system

Besides, Fig. 1 is a 'rich picture' diagram [15-16] that illustrates structure underlying the work environment can helps to identify elements that are relevant to the printing service system. For example, technician, toner inventory system, and network printers. Hassan *et al*. [14] has discussed on developing a system with environment awareness capability and how to capture and present information about resources in the environment based on a 'rich picture' diagram.

Fig. 2 shows elements involve in network printing service system and information that is available and accessible offered in the computing system environment. For example, User 1 having problem with her default printer, Printer-1, which is paper tray is empty. The technician responsible for maintenance of all printers network including Printer-1 is Azman, and he is currently available. Fig.3 is an example of printer monitoring system. Another printers, called Printer-2, Printer-3 and Printer-4, are available, however, Printer-3 is low in toner. The available and nearest printer to User 1 is Printer-2 located in User 2's room.
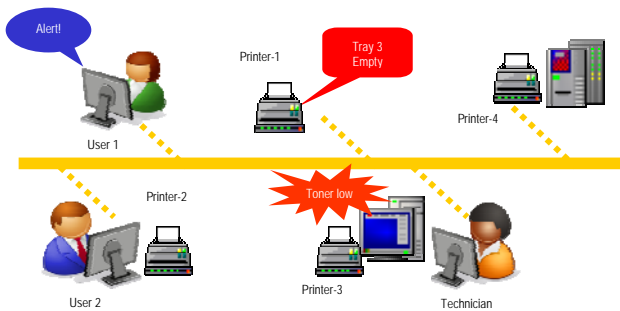

Fig. 2. Role of *USher* in printing service system

Fig. 3. Printer monitoring

In practice, a more convenient recovery strategy for the users is aware of other available resources in the environment. For example, redirect the print job to another nearby printer or knowing that the technician in charge is available for assistance. Ensuring that appropriate corrective actions are taken and identifying

recovery strategies that users may wish to consider requires detailed information of a computing system's continuously changing environment.

4.3 The Implementation

A prototype, called *USher*, is an alert application developed to increase user awareness of the current status of printing service and potential problems (e.g., delays) informed by information obtained from computing systems operating environment. *USher* notifies users about the current status of the printing service and alerts them to potential problems, such as delays that might be caused by a long queue of jobs for a default printer.

The screenshot in Fig. 4 shows an alert message displayed on the user's desktop when *USher* detects that the printer is low in toner. In this example, the alert message informs the user to press 'Go' button on the printer to resume printing her job. *USher* also informs that the quality of the print out might be affected due to printer is low in toner.

USher also suggests standard corrective action for particular faults to the user. In this example, *USher* informs user that the printer is low in toner and asked user to install new toner cartridge. Furthermore, if user looking for assistant, user can contact the technician in charge, Azman, and system aware that he is in his office. Diagnosis system [7] can also be activated from *USher* if the user wishes to troubleshoot a printing problem such as poor print quality. In addition, Fig. 5 shows screenshots of information gathered by *USher* from computing systems environment that can facilitate users recovery from service failures.

Fig. 4 *USher* application

Environment awareness required for recovery in the printer domain includes printer details, status (e.g., toner level) and technician in charge and his current availability. *USher* is able to identify recovery strategies to avoid failures by using the information obtained from its operating environment, in which it is able to:

- inform status of printers in local network

- suggest a standard corrective action (e.g., replace the toner cartridge) for particular status (e.g., out of toner)
- identify potential problems (e.g., delay)
- locate a nearby printer
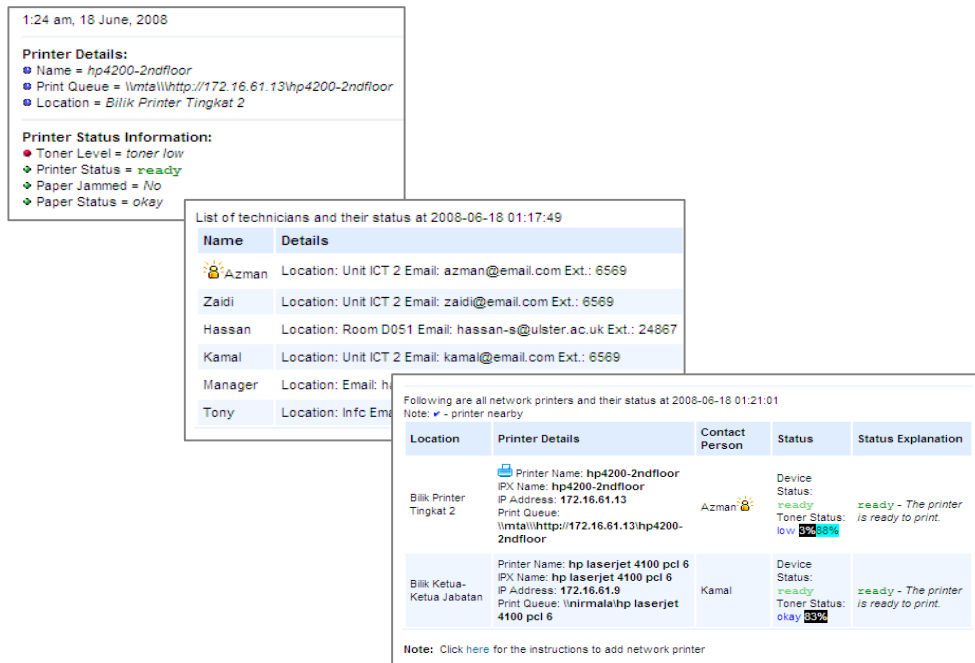- contact person in charge to take corrective action

Fig. 5. Information gathered from environment awareness

5. Conclusions

Environment awareness plays an important role in helping users recovery from service failures, for example by suggesting the use of alternative resources in the environment that provide the same service. Another benefit is that the information can also be used to increase user awareness of resources available in a computing system environment and how they can be used to avoid potential problems. Real-time monitoring of the printing service by *USher* has the important benefits of enabling the user to help minimize the occurrence and the effects of service failures. The distinguish benefits are that recovery may often be possible even if the fault cannot be diagnosed, or assistance from a technician is not immediately available. In most situations, users are offered an option of redirecting her print job to another printer. In this way,

USher encourages the fully utilizing resources and sharing of information available in the environment to support computing services.

We have present in this paper that awareness of resources that are available and accessible in the environment is essential for recovery to ensure continuity of services in the presence of failures. Environment awareness for recovery process including aware about the system's event and services, accessible and available resources relevant to the services. The aims is to provide useful information required for user to complete his/her task or part of a task in the present of faults or failures. The benefits of environment awareness in computing services are include:

- Able to provide user with the facts so that they could avoid problems
- Able reduce number of users facing service failures
- Enable users to adjust the computer service to meet their needs

However, we have noticed that there is loads can be improved and promoted from here and thus we plan to carry out in future. To begin with, we plan to extend the experiment. The application developed as a proof-of-concept is a prototype, and we are currently making it more autonomous. For example, to automate particular corrective action informed by the environment awareness, such as redirecting an urgent job to a printer that is currently idle.

Secondly, we plan to improve the functions become more dynamic and flexible. The most important one is in suggesting recovery strategies, where currently is based on rules and common strategies. For example, recovery strategies by *USher* based on information of technician in charge and other available printer only. However, it is difficult to implement an application that able to suggest appropriate recovery strategies in accordance with problems or faults that occur in dynamic environment. This might concerns on methodological approach, in which to develop a system that know of what kind of recovery strategies the system should support according to environment awareness.

Finally, further investigations are required and we are interested in applying this concept to other applications, for example network user in client-server environment. We believe that many applications can take advantage of this concept and this will also help us refine our approach.

References

[1] Avizienis, A., 1967. Design fault-tolerant computers. *In: Proceedings of the 1967 fall joint computer conference*, Washington: Thompson Books, 733-743.

[2] Avizienis, A., 1997. Toward systematic design of fault-tolerant systems, *IEEE Computer*, 30 (4), 51-58.

[3] Randell, B., 1975. System structure for software fault tolerance. *IEEE transactions on software engineering*, SE-1 (2), 220-232.

[4] Randell, B., 2000. Facing up to faults. *The computer journal*, 43 (2), 95-106.

[5] Bustard, D.W., Hassan, S, McSherry, D. and Walmsley, S., 2007. GRAPHIC illustrations of autonomic computing concepts. *Innovations in systems and software engineering*, 3 (1), 61-69.

[6] Horn, P., 2001. Autonomic computing: IBM's perspective on the state of information technology. *AGENDA 2001*, Scottsdale, AR, IBM TJ Watson Labs.

[7] Hassan, S., McSherry, D. and Bustard, D.W., 2006. Autonomic self-healing and recovery informed by environment knowledge, *Artificial intelligence review*, 26 (1-2), 89-101.

[8] Nelson, V.P., 1990. Fault-tolerant computing: fundamental concepts. *IEEE Computer*, 23 (7), 19-25.

[9] Johnson, B.W., 1996. An introduction to the design and analysis of fault-tolerant systems, *In*: Pradhan, D.K., ed. *Fault-tolerant computer system design*. Prentice Hall, 1-87.

[10] Fowler, H.W., Fowler, F.G. and Thompson, D. *The concise oxford dictionary of current English*. Clarendon Press, Oxford, UK, 1995.

[11] Brachman, R.J., 2002. Systems that know what they're doing. *IEEE intelligent systems*, 17 (6), 67-71.

[12] IBM, 2003. *An architectural blueprint for autonomic computing*. IBM Corporation. Available from: www-03.ibm.com/autonomic/pdfs/ACwpFinal.pdf

[13] Kephart, J.O. and Chess, D.M., 2003. The vision of autonomic computing. *Computer*, 36 (1), 41-51.

[14] Hassan, S., Bustard, D.W. and McSherry, D., 2006. Soft systems methodology in autonomic computing analysis. *In*: *Proceedings of the UKSS international conference*, *11-13 September*, *Oxford*, 106-115.

[15] Checkland, P.B., 1981. *Systems thinking, systems practice*. Chichester: Wiley.

[16] Checkland, P. and Scholes, J., 1990. *Soft systems methodology in action*. Chichester: Wiley.

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