Chapter 5
Flexibility and Security of Careflow Systems Modeled by Petri Nets

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ABSTRACT

The purpose of this chapter is to present an interplay of two important structural and behavioral features of robust intelligence in careflow systems, called flexibility and multi-level security. The chapter deals with design and analysis of careflow systems, i.e. workflow systems with applications in broadly understood healthcare industry. The authors focus on providing a robust intelligence to such systems in a form of structural and behavioral flexibility. They analyze several forms of design and run-time flexibility. However, the authors focus on case handling systems, exception handling, and on careflow systems with sub-processes called worklets. They also present how to model multi-level security within careflow systems that already have desired forms of flexibility. This implies that flexibility and security are conceptually independent and can therefore be modeled with Petri nets separately and incrementally in sequential order, first flexibility and then security. The authors apply Petri nets and colored Petri nets as conceptual modeling tool. They use example of Cutaneous Melanoma (CM) to illustrate some of our considerations.

INTRODUCTION

Recently (Arrow et al., 2009) a report of a group of healthcare professionals was published that formulates eight principles based on which a reform of American healthcare system must be based. Principle number 4 states: "*Develop a health information technology infrastructure with national standards of interoperability to promote data exchange."* This and remaining recommendations of the report address predominantly issues of healthcare databases and their interoperability. However, they do not address even more important issue of computerization of healthcare processes that are based on published medical guidelines for various disease, chronic healthcare, and medical

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procedures. Computerization of such processes can reduce the number of medical errors caused by medical personnel and, as a result, can improve performance and cost of the overall healthcare system.

This chapter deals separately with two important features of modern Healthcare Information Systems (HCIS): flexibility in design and execution of clinical procedures, and security of patient's medical and personal information. We focus on a special class of HCIS called Careflow (CF) systems, which are workflow systems applied to healthcare domain. Flexibility and security are conceptually unrelated, i.e. one can first develop a flexible careflow Petri net model that is later augmented with desired security features. As a result, flexibility and security can be modeled incrementally within the Petri net paradigm (Girault and Valk, 2003). Taking into account the fact that Petri nets can be directly implemented in hardware or software this allows direct deployment of careflow systems that are both flexible and possess desired multi-level security (Gami and Mikolajczak, 2007a).

Flexibility (Adams et al., 2005) is important for healthcare providers because it offers a desired change to otherwise hardwired workflow definition. It also equips healthcare (HC) providers with a "sense of being in control" of the medical and clinical procedures that are otherwise completely controlled by related software or information technology (IT) environment. Flexibility can be perceived and implemented as static (at design time) or dynamic (at run time). We consider both aspects of flexibility within the Petri net modeling framework.

Security in HCI systems refers both to secure access as well as to integrity of patients' medical and personal information. Quite often security in HCI systems is multi-leveled and includes changing reading and writing privileges to various healthcare providers (physicians, nurses, administrative assistants, etc). For this reason we use Multi-level Security (MLS) models in our considerations.

Our objectives for this chapter are threefold: to show how Careflow systems are modeled by Petri nets, to show how various security features can be incorporated into the Petri net models of Careflow systems, and to show how flexibility can be modeled and represented within the Petri net modeling framework. We address both design time flexibility and run time flexibility.

BACKGROUND

Desired features of future HCI systems are: personalized health care, careflow processes that produce data and adopt themselves to changing realities, and participatory decision making, among others. These HCI requirements lead to expectation of change in careflow systems' definition. Careflow processes that have desired change characteristics include: dynamic careflow processes, adaptive careflow processes, and, in general, flexible careflow processes.

Flexibility can be informally defined as an ability of the careflow process to execute on the basis of a loosely, or partially specified model, where the full specification of the model is made at run time, and may be unique to each instance of the careflow process. Modeling framework that offers true flexibility has to take into account factors, which influence the paths of unique instances together with the careflow process definition. We advocate an approach that aims at making the process of change as part of the careflow process itself. We use the notion of an open instance that consists of a core careflow process and several pockets of flexibility. We present a framework based on this notion – it makes use of special build activities that provide functionality to integrate the process of defining a change, into the open careflow instance. Adaptive careflows can be represented by Petri nets. In such case they are called Adaptive Careflow nets (Schonenberg et

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