Petri net methodology for solving healthcare management issues

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Abstract. Various approaches of Petri nets can be achieved as system security and information flow in the healthcare recording system inside any medical or health-related business. Petri net system formal modeling is essential as well as important to track down the records and secure information inside a preformed health organization. In this paper, we mainly focused on the formal model Petri net which security mechanism is controlled by public key encryption where PN based modeling is preferred. This Petri net is a mathematical modeling to solve graphical notation for step by step processes that include choice, repetition, and circumstantial execution. Petri nets offer widely mathematical applications of discrete and continuous event execution semiotics, with an efficient mathematical analysis processing theory. We sure that our formal model will lay a solid foundation to minimize the risks and overcome the security risks in the healthcare industry.

1 Introduction

The healthcare management system is one of the most important and necessary systems which maintains various kinds of information and records of casualties or patients as well as medicinal related personnel daily [1]. However, the information of every patient with corresponding departments should be regulated properly inside the hospital or the related organization as well as must be flexible for convenience. [2] There are lots of models proposed regarding the security as well as for the purpose of flexibility and reliability for information flow and data management such as [3] a discrete-event simulation system to model antibiotic distribution centers and suggest optimal staffing levels, spreadsheet-based software known as Flu Surge for Pandemic influenza is also a concern, An agent-based model known as PHIMs (Public Health Interactive Model & simulation) is described in as an interactive simulation environment, etc.

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However, [4] the application of Petri net theory to the problem of healthcare modeling is not common but only five instances of research on the topic could be located. The different redesigned methodology is applied to the problem of intake procedure for new patients requesting non-urgent care at a mental health institution. These design practices are typically associated with commercial applications, but they were employed here for a redesign of the intake system for a flexible information flow[5]. Both the original and new intake procedures were modeled as a colored Petri net simulation, which generated results (average, low and high) for both flow time and service time. A similar theme plays out in which combines business process modeling and Petri net theory with the purpose of improving large-scale software system design [6]. The chosen process is the Design & Engineering Methodology for Organizations (DEMO), which "studies communication, information, and action within the context of an organization". The system is then graphically represented using Petri net. Of interest is the example where a medical center's patient admission system is modeled using this approach and analyzed using existing Petri net tools for structural issues such as deadlock and conflict [7][8] [10].

In this paper, we generally focused on the Petri net model in the healthcare record where data and information are easily viable in regarding different unit of any health organization with convenience and security. Here several approaches are made to analyze Petri nets such as the enumeration of all possible states; reachability tree which identifies different nodes and change in the standard of Petri nets with cloud security [11][12].Moreover, the formal model is described below for with more clarity.

2 A formal model of Petri net representing health care record.

Petri nets is a mathematical modeling of parallel and distributed system for solving a graphical documentation for integrated and validated that include choice, duplication, and coincidental execution. Petri nets offer widely mathematical applications of discrete and continuous event execution semiotics, with an efficient mathematical analysis processing theory[9] [Carl Adam Petri].

A formal basic Petri net N holds two kinds of nodes, P and T, accordingly called places and transition, a set $F \subseteq (P \times T) \cup (T \times P)$the nodes directly connected with arcs, the marking of initializing $M_0 : P \to N$ that set of places is mapping into set N is totally non-negative integers.

The concept of Petri net is offer to variety of token nations. Tokens have own identification method, which possibly data have random values. The places contain complex data type security method. Appling to a formal model of Petri Net representing healthcare Record is tuple $\sum, P, T, A, H, Q, L, W, I$ where

$\sum$ is a finite set of non-empty set the type of initialization data value operations and function should be used in arc expression, guard, P Places is a finite set, T transition is a finite set, A arcs is a finite set :$P \cap T = P \cap A = T \cap A = \emptyset$,$H$ is a function node $H: A \to (P \times T) \cup (T \times P)$. Q is mapping $Q: P \to \sum$. The function Q mapping every place p to a kinds Q(p), however that per token on p might have a data value be part of Q(p). L is guard function. T is characterize from into expression specific $\forall t \in T$ type$(L(t))$ = Boolean and type$(H\ ar(L(t)) \subseteq \sum$. Per each transition $t \in T$.the Boolean expression is a guard of t , there is all variable has kind that be part of $\sum$. W is a function of arc expression. A is characterize into expression such that:$\forall a \in A$: type $(W(a) = Q(p)M\ Q$ and type of $(H\ ar(W(a)) \subseteq \sum$. There p is the

place of $H(a)$. Per each arc $a \in A$. The type of $W(a)$ is the multiset $Q(p)M\ Q$, however measure that $W(a)$ necessity appraise to multiset accomplished kind of modification place p. furthermore, all variable in an arc expression $W(a)$ has in $\sum$. I is function of initialization. its characterize by P within expression such that $\forall\ p \in P$: type $(I(p) = Q(p)M\ Q.I$ maps every place $p \in P$ within expression that might be type of $Q(p)M\ Q$. A set place followed by a set of transition such as place (P): $(P1), (P2), (P3), (P4), (P5), (P6), (P$ and transition (T): $(T1), (T2), (T3), (T4), (T5), (T6), (T7), (T8)$. Moreover, the initial marking as M_0 $(0,1,0,0,0,0,0,0)$. The set of input and output secure the patient information record integrated and validated implementation and persistent storage system with CRUD (create, retrieve, update, and delete)in the medical device networking system is done by matrix for as in table I and table II and figure 1. The result is $M_0\{1,0,0,0,0,0,0,0\}$.

Table 1. Place Specification

Name	Specification
P1	Physician
P2	Patient connect with physician
P3	Medical superintendent receives the record packet
P4	Nurse receives the record packet
P5	verifying the destination node packed and is ready to send the record
P6	Place Discard
P7	Pharmacist has received record packet
P8	All data record is updated

Table 2. Transition Specification

Name	Specification
T1	Physician updated the patient record
T2	Patient record is send to the medical superintendent
T3	Medical superintendent check the record
T4	Nurse create the new record
T5	Nurse is allotment the record number of patient
T6	The record verification in case its destination
T7	The pharmacist is transmit record to the medical superintendent
T8	Physician have up to date record of the physician

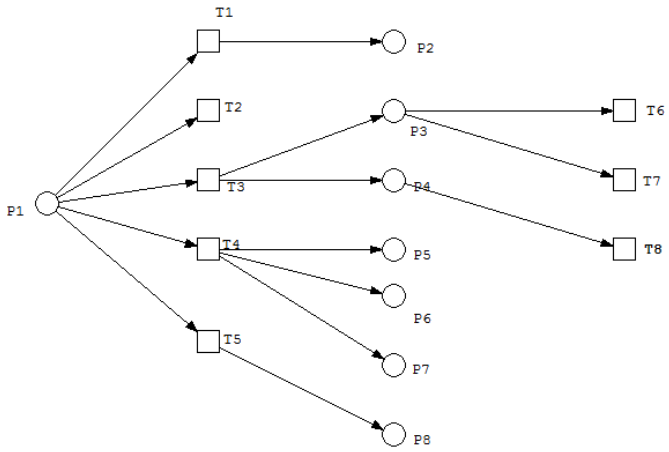

Fig1. Diagram of medical device networking.

$$\textbf{Input Metrics} \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \end{bmatrix}$$

$$\textbf{Output Metrics} \begin{bmatrix} \mathbf{1} & \mathbf{1} & \mathbf{1} & \mathbf{1} & \mathbf{1} & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{1} & \mathbf{1} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{1} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} \end{bmatrix}$$

Petri net input and output matrix representation of net, here is $P \times T \; and \; T \times P$ (p rows and t columns), p is the number of place and t is the number of transition.

3 Conclusion

In conclusion, we precisely presented a formal security model which can be used to analyze the information flow in health care system. The entities present in this system can be assigned different security levels belonging to a given security encryption technology. Furthermore, every information is assigned a security level which captures the confidentiality level in any healthcare record. It is also potential to specify in a formal way different security strategies for the movement of entities with a system and information flow is smooth. The resulting formal model can then be represented by a suitable formal model, and its dynamic properties analyzed using the existing verification methods and tools developed for Petri nets.

Acknowledgements: This work was supported by National Natural Science Foundation of China Grant No.61603273, by Tianjin Application Foundation and Advanced Technology Research Project under Grant No. 14JCQNJC00300, and by Natural Science Foundation of Tianjin under Grant No. 16JCYBJC18500.

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