Analysis Patterns for Patient Treatment Records

Tami Sorgente, Eduardo B. Fernandez, and Maria M. Larrondo Petrie
Dept. of Computer Science and Engineering,
Florida Atlantic University, Boca Raton, FL 33431
tsorgent@fau.edu, ed@cse.fau.edu, maria@cse.fau.edu

Abstract

We discuss analysis patterns that describe some aspects of recording information in a medical system for patient treatment. The Patient Treatment Records pattern includes two simpler patterns that describe the creation and maintenance of the patient record and the assignment of the hospital assets for use by the patient. The Patient Record pattern models the hierarchical structure of the patient information, medical history and treatment instance. The Asset Structure and Assignment pattern describes the assets assigned for each unique treatment instance. Together, these patterns represent the relationships between the patient, the medical history, the treatment instance, and the hospital assets. When a patient enters the hospital a treatment instance is created and added to the Patient Record pattern. The Asset Structure and Assignment pattern denotes the location, doctors, and nurses assigned to the patient. These component patterns have value on their own right.

1. Introduction

The medical information of a patient is one of the most sensitive types of information. Medical information is collected from the moment a person is born until her death. Medical information typically includes aspects of a person's physical health such as treatments, medicines and diagnoses. In addition to this health information, a medical record may also include information about substance abuse, sexual behavior, family relationships, and private thoughts expressed through psychotherapy. The Patient Treatment Records Pattern focuses on the private and sensitive nature of this information and the need for maintaining accurate and organized records. A patient is admitted to a healthcare facility where all pertinent information is recorded. A physician and other facility assets are assigned to the patient. Following treatment the patient is discharged. This pattern describes only some of the aspects of patient treatment, which include the creation and maintenance of the patient record and the assignment of the assets for use by the patient. This pattern describes a general non-emergency treatment situation and does not consider the details of patient diagnosis and treatment.

In addition to the medical personnel, there are various actors involved in handling this information. The organization and access control of the private medical information of each individual is complex and fragmented [Epc02]. To provide guidelines for the protection of these records many countries, including the US, are enacting laws that regulate the use of electronic patient records. The British Medical Association in 1996 put strong controls on UK patient records. In the US the recently approved Health Insurance Portability and Accountability Act (HIPAA) tries to do similarly [Fed03]. Germany, France, and Iceland are other countries that have implemented this type of regulation. A pattern is a good way to simplify the steps needed to implement systems that comply with some parts of this regulation. In addition, this pattern could be used as a starting point to develop security models for medical information as in [Fer04].

The Patient Treatment Pattern describes the treatment or stay instance of a patient in a hospital. The hospital may be a member of a medical group. Each patient has a primary physician, an employee of the

hospital. Upon admission the patient record is created or information is updated from previous visit(s). Inpatients are assigned a location, nurse team, and consulting doctors.

The Patient Treatment Records Pattern is a *Semantic Analysis Pattern* (SAP) and corresponds to requirements expressed as a set of use cases [Fer00]. The analysis model is developed from the use cases. We first present its two component patterns, Patient Record and Assignment of Assets for Patient Treatment, which we combine later into Patient Treatment Records. These component patterns are themselves examples of SAPs and have value on their own right. Figure 1 shows the Use Case diagram that corresponds to some of the typical needs of patient treatment and which define the structure of the Patient Treatment Records Pattern. There are other use cases such as diagnose, perform patient treatment, and billing that have been left out for simplicity.

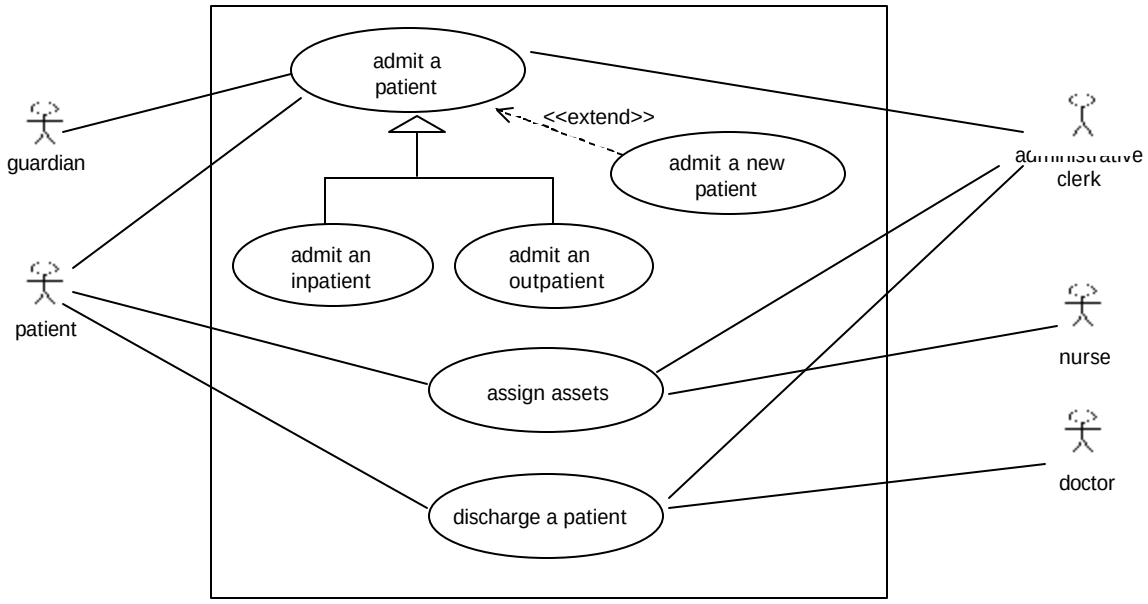

Figure 1 Use Case diagram for Patient Treatment

2. Patient Record

2.1. Intent

Describes the structure of patient records and the process of creating and maintaining them for a stay or treatment in a hospital.

2.2. Example

A patient encounter at a typical hospital is documented in a paper record, separated by dividers. This record is referred to as a patient chart. The patient encounter chart from Boca Raton Community Hospital contains fifteen dividers. The facility maintains a separate chart for each encounter within the hospital. This chart is created upon admission to the hospital, whether as an inpatient or outpatient. This hospital is not a member

of a group; however, if a patient is not new to the facility there will be a record of previous visits all documented as separate charts. The patient has a patient identification number for his cumulative medical record and is assigned a unique number for each encounter. Upon admission a patient fills out a consent form and his chart may be updated with pertinent information from a previous visit. The patient chart remains with the patient throughout the stay in the hospital. When a patient is discharged from the hospital the chart is added to the medical record and the medical records department is the custodian of the record. The hospital is currently working on the transition of information from paper-based to digital format.

2.3. Context

A hospital or any medical institution where patients receive treatment.

2.4. Problem

Maintaining accurate records is crucial for patient treatment. A poor record may result in erroneous treatments, loss of insurance, or other problems for the patient or the hospital. How do we keep an accurate picture of what happens during the stay of a patient at a hospital for treatment?

The solution to this problem is affected by the following forces:

- Patient characteristics, e.g., age, sex, occupation, race, weight, and others, may have an effect on the diagnosis and treatment of the patient and it is important to keep this information accurate.
- We need a detailed record of what has been done to a patient during a specific stay at the hospital. This is necessary for medical, billing, and legal reasons.
- Patients may return to the hospital and we need to relate new treatments to past treatments.
- There may be different types of patients that we need to classify. Otherwise, the patients or the hospital may incur unnecessary expenses.
- Patients may not be responsible for their decisions or their expenses, we need somebody responsible for the patient.

2.5. Solution

Maintain a medical history for each patient. This medical history typically contains insurance information and a record of all treatments within the medical group. If the patient is new to the medical group a patient record and medical history will be created upon admission. If the patient has been treated in any facility within the medical group there will be an existing patient record and a medical history, which may need to be updated. A treatment instance is created for all patients admitted and updated throughout the patient's stay. The treatment instance will subsequently be added to the patient medical record upon patient discharge. A person or guardian is responsible for each patient. We classify patients into inpatients and outpatients. Use cases realized by this pattern include Assign a Guardian, Modify Medical History, and Admit a New Patient.

Figure 2 shows the structure of patient records. A unique stay or **TreatmentInstance** for every patient is created upon admission to the hospital. The patient may be admitted to the hospital as an **Inpatient** to stay in the hospital, or he may be admitted as an **Outpatient**, in which case he will receive treatment but will not stay at the hospital. The treatment instances are collected into the **MedicalHistory**. A **Guardian** is responsible for each patient. Guardian can be seen as a role in that a Patient may be its own guardian. Additional relevant patient information is recorded into **PatientInfo.**

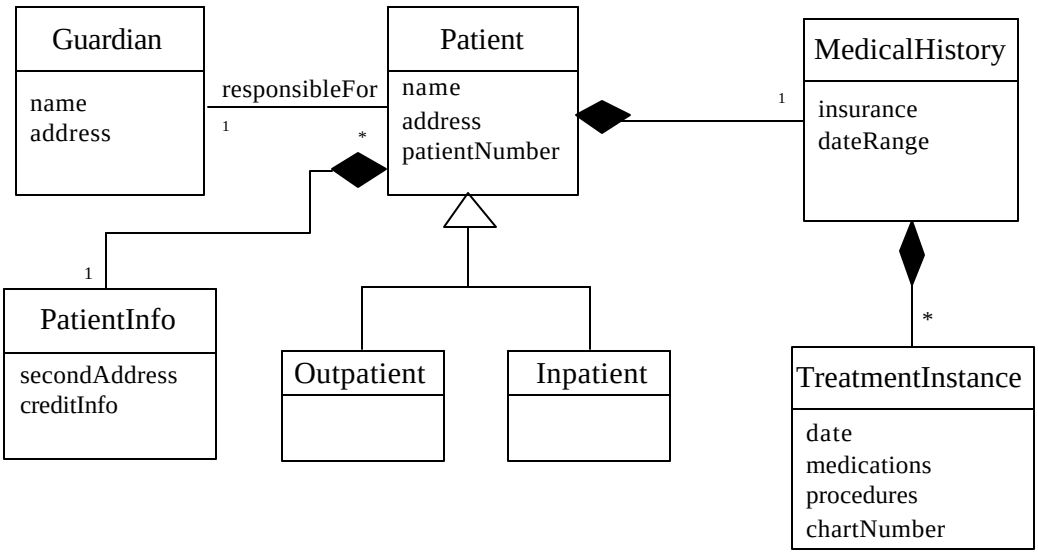

Figure 2 Class diagram for Patient Record

The sequence diagram of Figure 3 describes the process of admitting a new patient. The guardian provides information to an administrative clerk, a patient record is created, patient information is created, a medical history is created, and a unique treatment instance is created for the current treatment or stay.

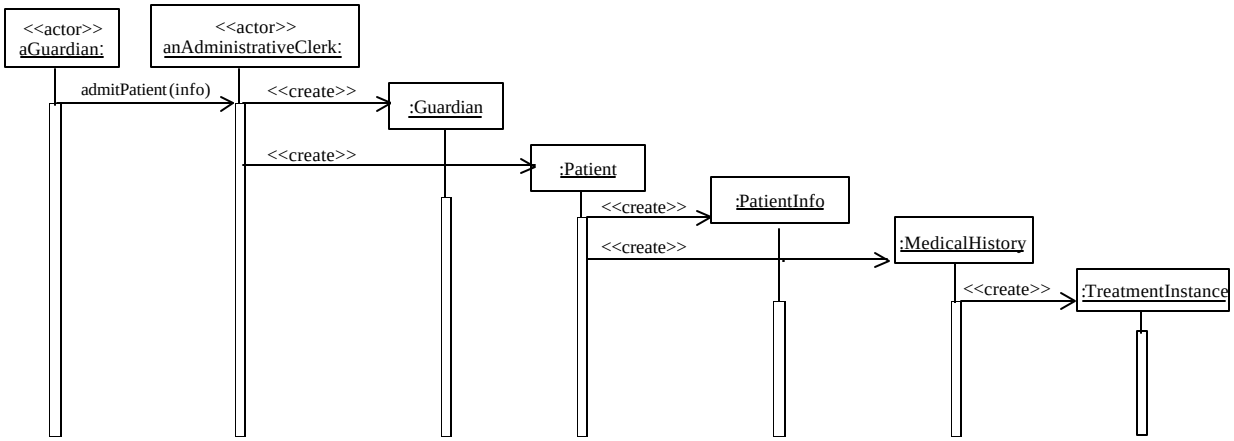

Figure 3 Sequence diagram for admitting a new patient

Figure 4 shows a statechart for the class TreatmentInstance of a patient. This unique treatment instance is created upon admission. The patient will begin the treatment in the medical facility. The first step in treatment is diagnosis. Following diagnosis the patient will be under treatment. At some point, treatment may become suspended. When treatment is complete, the patient is discharged and the treatment instance is added to the medical history. At any point in the treatment the patient could discontinue treatment or possibly pass away (described by the superstate that surrounds the treatment states).

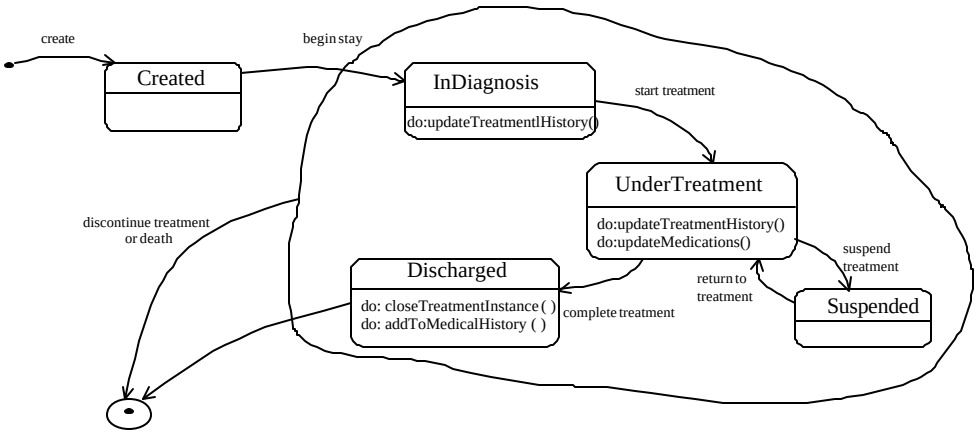

Figure 4 Statechart for class TreatmentInstance

2.6. Consequences

This pattern has the following advantages:

- We can keep any relevant information about patients.
- A unique treatment instance is created for each hospital stay. This instance keeps track of the actions performed as part of the patient treatment.
- Each treatment instance is added to a medical history. This allows relating new treatments to old ones.
- We can classify patients according to the type of treatment needed.
- Each patient has a guardian to make decisions and handle expenses.

The pattern has the following liabilities:

- The pattern does not describe standard admission documents, such as Admission record, Discharge record, and others. These vary in different institutions and must be added according to requirements.

2.7. Known Uses

Any hospital or clinic maintains patient records. For example, if a patient visits the Boca Raton Community Hospital for the third time there will be a record of previous visits.

2.8. Related Patterns

The Medical History is a collection of TreatmentInstances, the Collection Pattern is a pattern used to group similar objects [Bus96]. Fowler discusses an Observation pattern in [Fow97] that indicates measurements and other observations in a patient and would complement our pattern. Variations and extensions of the observation pattern relevant to our patterns are discussed in [Yod01].

3. Assignment of Assets for Patient Treatment

3.1. Intent

Describes the structure of the assets needed for patient treatment and their assignment to patients. Assets typically include doctors, nurses and treatment locations.

3.2. Example

When a patient is admitted for treatment the patient will be assigned to nurses, locations, and consulting doctors. These assignments may change and need to be updated during treatment as the patient is relocated.

Many times in a busy hospital setting it is difficult to keep all of this information updated throughout the patient's stay. The Assignment of Assets for Patient Treatment Pattern provides a clear representation of the relationships between the patient and the hospital assets.

3.3. Context

A hospital or medical group that provides patient treatment.

3.4. Problem

How does the hospital keep track of which doctors and nurses are assigned to the patients and in what locations of the hospital is the patient assigned for treatment?

The solution to this problem is affected by the following forces:

- Patients receive treatment for various ailments in different areas of a hospital and we need to keep track of all treatments in all locations of a hospital.
- Patients may receive treatment from various doctors and nurses of the hospital and we need to keep track of all treatments by all medical employees.
- In order to assign the proper personnel and physical facilities to patient treatment, we need a systematic categorization of these assets.

3.5. Solution

Assets of the medical group are assigned to a patient through associations. Figure 5 shows associations between classes **Doctor**, **Nurse,** and **Location** and class **Patient** that describes the corresponding assignments. In particular, all patients are assigned a primary doctor while inpatients may also be assigned consulting doctors. Locations include the room assigned to an inpatient or other places for specific treatments. This pattern realizes use cases Assign Assets to a Patient, Modify Asset Assignment, and Assign Nurse to a Location. The same use case may differ depending on whether the patient is an inpatient or an outpatient.

The assets of the medical group are organized in a hierarchical arrangement that describes their physical or administrative structure. Figure 5 describes the hierarchical arrangement of a **MedicalGroup** that includes some **Hospitals**. In turn, each hospital includes some **Buildings**. Each treatment **Location** is part of a building. The class **Employee** classifies the types of personnel that are assigned to patients.

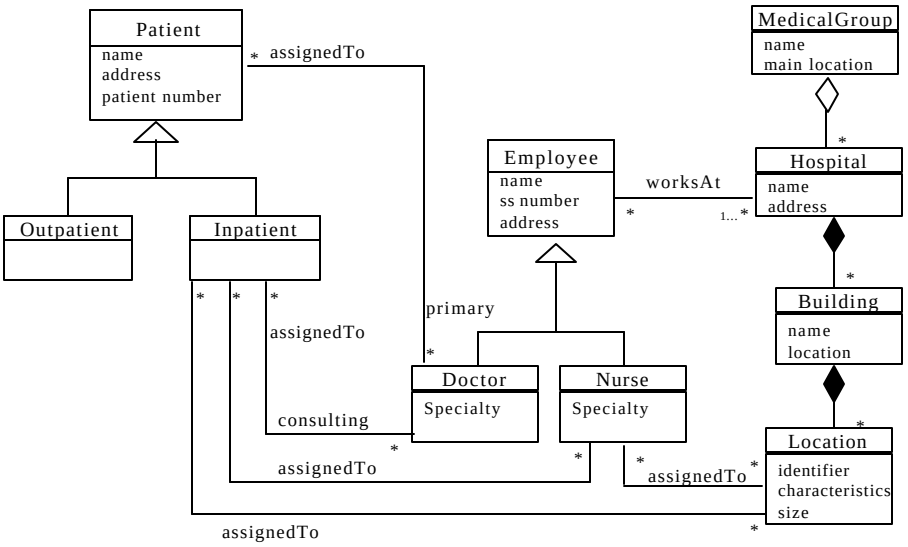

Figure 5 Class diagram for Asset Assignment

Figure 6 shows a sequence diagram for assigning assets to an inpatient, the location where the patient will be treated is checked for availability and assigned to the patient. After that, doctors and nurses are assigned.

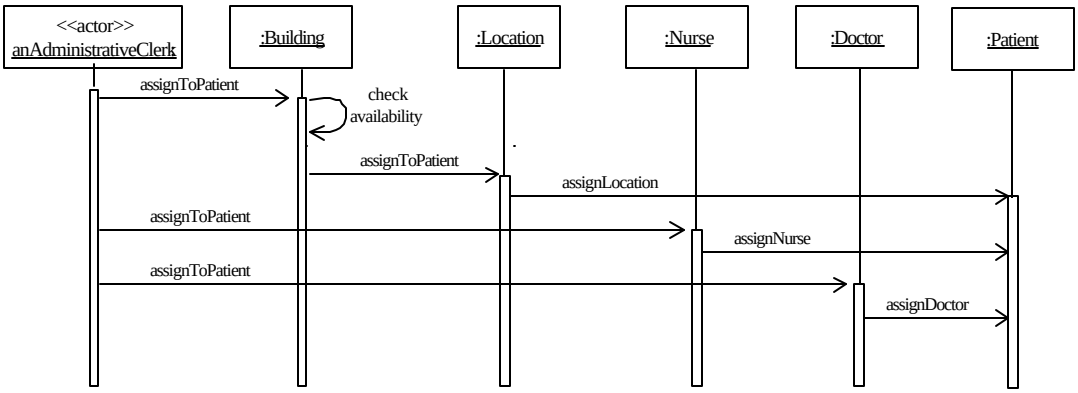

Figure 6 Sequence Diagram for Assigning Assets to an Inpatient

3.6. Consequences

This pattern has the following advantages:

- We can conveniently find out the hospital personnel assigned to a patient or to specific locations and where the patients are.
- Changes to assignments require only adding or deleting links in associations.
- A hierarchy of assets allows control and assignment of assets to be more efficient and convenient.

It also has some liabilities:

- Not every type of relevant asset is represented. For example, other employees or medical equipment may be assigned for patient treatment. However, they can be added ad hoc.

3.7. Known Uses

Many medical facilities organize their assets in a hierarchical structure and need to keep track of asset allocation for insurance and liability reasons.

4. Patient Treatment Records Pattern

4.1. Intent

Describes the process of keeping the information for admitting, assigning assets, and treating a patient in a hospital.

4.2. Example

A patient enters a medical facility for treatment. This patient has previously been treated at this facility. The information on the history of the patient is a series of paper charts all filed in the archives of the medical records office. When the patient is admitted for treatment a new paper chart is created. The information from previous visits will not be immediately available. The staff assigned to the patient may need information form the previous visits. In addition the new chart contains information about the current treatment. When the patient is discharged all the information needs to be added to the patient history and the medical facility assets need to be released for use by other patients. The Patient Treatment Records Pattern models the real life uses of this information and links it all together. In this age of digital information systems a clear understanding and organization of this information is essential for quality patient care and for billing, liability, and statistical purposes.

4.3. Context

A medical facility that offers patient treatment. The facility may be a hospital that is a member of a medical group.

4.4. Problem

In order to treat patients properly, patient records and assignment of assets to patients need to be organized, maintained, and managed efficiently and accurately.

The solution to this problem is affected by the following forces:

- Patients may receive treatment from various doctors and nurses of the hospital and we need to keep track of all treatments by all medical employees.
- Patients may return to the hospital and we need to relate new treatments to past treatments.
- There may be different types of patients that we need to classify.
- Patients may not be responsible for their decisions or their expenses, we need somebody responsible for the patient.
- Medical institutions have a variety of employee jobs, a variety of buildings, and other assets. It is important to keep track of all this.
- In a medical institution employees and physical assets change frequently, and this information needs to be recorded and kept accurate. We need to assign the proper personnel and physical facilities to patient treatment and to do this we need a systematic categorization of these assets.
- We need to keep track of all asset assignments at any moment.
- Patients receive treatment for various ailments in different areas of a hospital and we need to keep track of all treatments in all locations of a hospital.

Above are the forces of the component patterns. In addition, we also have:

- Some of the assignments must be made as soon as the patient is admitted.
- A patient may be moved or reassigned during a stay and we need to document the new assignment.
- After the patient is discharged or leaves for any reason all assignments need to be released and the records updated.
- A patient may discontinue treatment at any time and the assets and information need to be linked.
- All assets used by the patient need to be explicitly described.
- Access to private patient information needs to be controlled.

4.5. Solution

The combination of the previous patterns provides functions to manage patient treatment in a hospital. Figure 7 shows the Patient Treatment Record Pattern. This pattern describes the process of admitting, allocating assets, and maintaining records of a patient in a hospital. The leftmost classes correspond to patient record details, including their medical histories. The Employee hierarchy classifies hospital workers that provide services to patients. The rightmost hierarchy describes physical assets of the hospital. Associations from the center and right groups to the Patient classes describe assignments of resources.

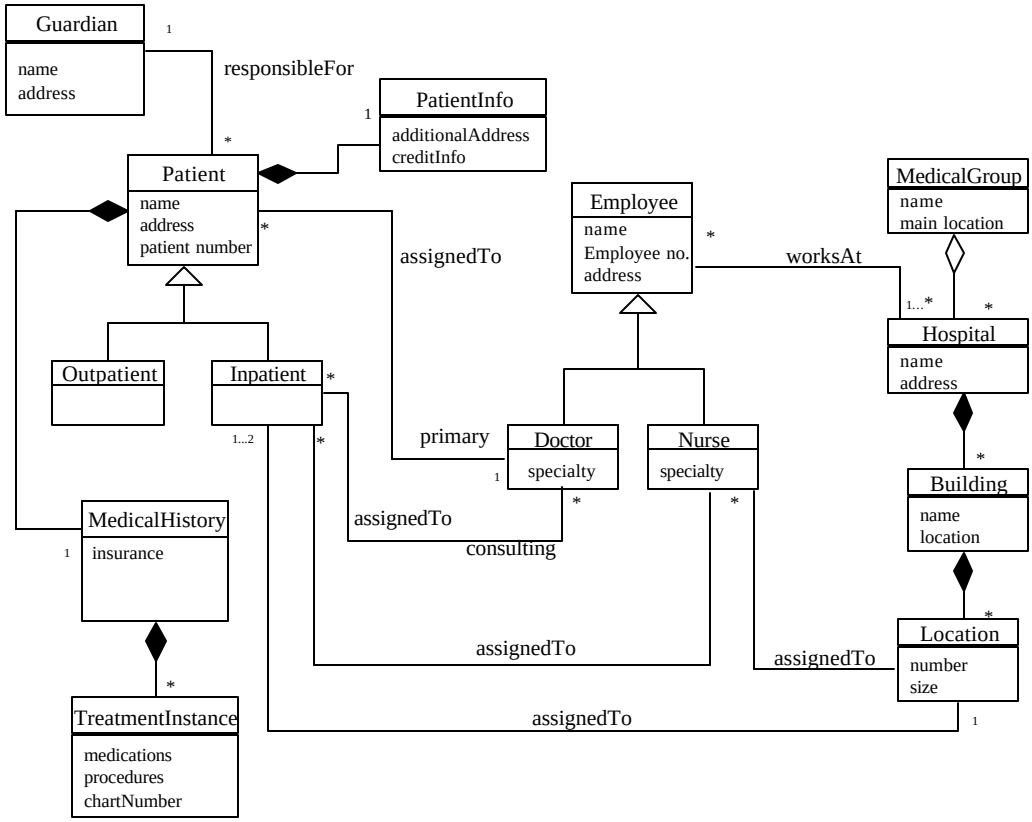

Figure 7 Class diagram for Patient Treatment Record

The sequence diagram of Figure 8 describes the process of discharging a patient. The doctor provides discharge information to an admissions clerk, the nurse, location, consulting doctors are released from the patient. Through the patient class, the treatment instance is closed and added to the medical history.

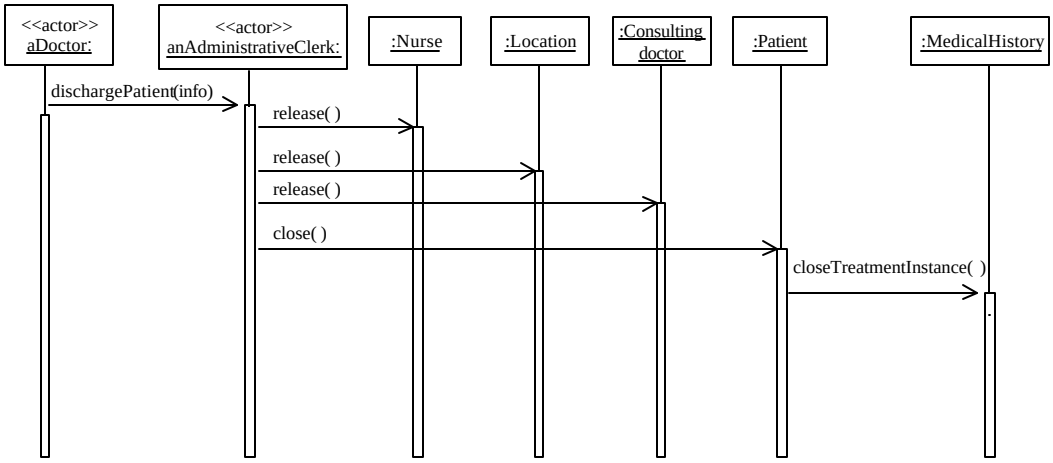

Figure 8 Sequence diagram for discharge a patient

4.6. Consequences

This pattern has the following advantages:

- The patient record is linked with the assets assigned to the patient.
- All information about a patient's stay is recorded and documented even if there are reassignments during that stay.
- When a patient is discharged, the treatment history is added to the medical history and all treatments within the medical group will be kept for future reference.
- If a patient discontinues treatment for any reason this information will be on record.
- All the assignments of personnel or physical resources are explicitly described.
- Role based access control can be used to protect this information. The access to patient treatment information can be controlled based on the role of the individuals [Fer97].

The pattern has the following liabilities:

- The pattern does not describe standard admission documents, such as Admission record, Discharge record, and others. These vary in different institutions and must be added according to requirements.
- Not every type of relevant asset is represented. For example, other employees may be assigned to patient treatment. However, they can be added ad hoc.
- It does not describe the breakdown of the medical chart and some of this information may need to be linked to locations or medical personnel.

4.7. Related Patterns

Repair Pattern – A patient enters a hospital for "repair", assignment is made for the repair and a record is kept [Fer00, Fer01]. Models for health systems that include similar requirements and complement these models are presented in [hl7] and [jah].

SiGCli- A pattern language for rehabilitation clinics management [Paz04] – Intended to follow and report the actions of a person who looks for rehabilitation treatment. This language includes an Identity Patient pattern to describe patients and some other aspects.

Acknowledgements

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