Modeling a terminology-based electronic nursing record system: An object-oriented approach

Hyeoun-Ae Park\textsuperscript{a}, InSook Cho\textsuperscript{b,\ast}, NamSoo Byeun\textsuperscript{c}

\textsuperscript{a} College of Nursing, Seoul National University, Seoul, South Korea
\textsuperscript{b} Department of Nursing, College of Medicine, Inha University, 253 Younghyun-dong Nam-gu, Incheon 402-751, South Korea
\textsuperscript{c} EzCareTech, Seoul, South Korea

\textbf{Abstract}

Objective: The aim of this study was to present our perspectives on healthcare information analysis at a conceptual level and the lessons learned from our experience with the development of a terminology-based enterprise electronic nursing record system—which was one of components in an EMR system at a tertiary teaching hospital in Korea—using an object-oriented system analysis and design concept.

Methods: To ensure a systematic approach and effective collaboration, the department of nursing constituted a system modeling team comprising a project manager, systems analysts, user representatives, an object-oriented methodology expert, and healthcare informaticists (including the authors). A rational unified process (RUP) and the Unified Modeling Language were used as a development process and for modeling notation, respectively.

Results: From the scenario and RUP approach, user requirements were formulated into use case sets and the sequence of activities in the scenario was depicted in an activity diagram. The structure of the system was presented in a class diagram.

Conclusion: This approach allowed us to identify clearly the structural and behavioral states and important factors of a terminology-based ENR system (e.g., business concerns and system design concerns) according to the viewpoints of both domain and technical experts.

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1. Introduction

The nursing record is the formal documentation associated with nursing care. In the past, the nursing record was merely a data repository that helped nurses to recall what they had done, whereas currently the record represents a resource for the reuse of primary information. To maximize the usefulness of the nursing record, computer-based nursing records have been introduced as a part of the computer-based patient record. The computer-based nursing record is more than a series of documents in electronic form—it will be the cornerstone of a new way of managing nursing information. With an electronic nursing record, data collected at the point of care can be used to assist nursing care at all levels of aggregation. As in an electronic patient record (EPR) system, the electronic nursing record has the ability to capture clinical information and represent it using controlled terminology, which is widely recognized as a necessity [1].

Nursing terminology has seen much progress in recent decades. Several national and international nursing organizations have identified a need for standardized terminology to facilitate the description, comparison, and communication of nursing-care activities across settings, population groups, and countries [2]. The recent trend toward developing a more

\textsuperscript{*} Corresponding author. Tel.: +82 32 860 8201; fax: +82 32 874 5880.
E-mail addresses: hapark@snu.ac.kr (H.-A. Park), insook.cho@inha.ac.kr (I. Cho), bns@ezcaretech.com (N. Byeun).
rigorous foundation for nursing terminology brings with it several potential benefits, including greater expressiveness and more extensive reuse of data from heterogeneous sources [3–5].

However, the existence of appropriate terminology for capturing nursing information does not necessarily solve the problem of how the information will be transformed from concepts in the nurses’ minds to codes in the computer’s database. Users of existing nursing information systems typically enter and retrieve structured data using so-called interface terminologies—terminologies that are optimized for end-user utilization, such as menu-driven data entry [6]. These terminologies generally take the form of enumerated classifications, such as the North American Nursing Diagnosis Association Taxonomy I. But it is now recognized that these types of terminologies may not be able to represent clinical information in sufficient detail [5,7,8] nor provide sufficient coverage [9]. The International Classification for Nursing Practice (ICNP) developed by International Council of Nurses (ICN), which is a combinatorial terminology, represents one attempt to address some of the problems associated with these traditional representations. However, the combinatorial nature of the ICNP makes it difficult to use directly, and this now appears to represent a barrier to acceptance by nurse users [5].

This article describes how object-oriented analysis and design can be used in developing and implementing a terminology-based electronic nursing record system (ENRS). Here we describe how to design domain models and implement a model database that allows greater expressiveness and reuse of data. In addition, this study can be used to improve a multidisciplinary development team’s understanding of the functions and data processing procedures in the design and development stage, as well as of future maintenance procedures. We also describe the issues and lessons learned through this modeling process.

2. Background

2.1. The initiation of an ENRS design

In 2002, the Department of Nursing at the Seoul National University Hospital, a tertiary teaching hospital with 1500 beds in Korea, initiated work on designing an ENRS that was planned as part of the development of a paperless electronic medical record (EMR) system for a new branch hospital with 900 beds to be opened in May 2003. An ad hoc committee with six nurse managers was formed to decide important issues such as the controlled vocabulary, the nursing information model, and the user interface views. The committee recognized that the primary objective of an ENRS is to help nurses to manage a patient’s trajectory by tracing care activities and documenting all the events of the care processes.

The committee decided to use standard nursing terminology in order to support multipurpose applications of nursing data such as quality improvement, decision support, and comparison of nursing services. The ICNP beta version developed by the ICN was selected as the standard nursing terminology due to its expressiveness and flexibility.

A nursing information model using a standard terminology was designed and tested by the authors through the previous study [10]. Fig. 1 shows the conceptual data flow between the front-end and back-end of an ENRS. The upper part of the figure presents the content of nursing records expressed...
According to the nursing process, core nursing data should be captured through the nursing process, which encompasses fragmented types of nursing documentation in various structured and unstructured forms. The lower part of the figure presents the components and roles of a terminology server and a clinical data repository.

A terminology server manages three types of controlled terminology: clinical, administrative, and reference. In this study, the ICNP beta version was used as the reference terminology in the form of controlled nursing statements consisting of three data categories: nursing diagnosis, nursing activities, and nursing outcomes. These statements were used by the end users to populate the clinical terminology during direct data entry. These data categories are generated by terminology managers through semantic combinations of the ICNP concepts—these are referred to as precoordinated statements. The administrative terminology is a subset of the clinical terminology that is used for statistical classifications and data comparisons across heterogeneous representations; examples are the NANDA Taxonomy, the Clinical Care Classification, and the Nursing Interventions Classification. The administrative terminology contains more abstractive and aggregated terms, and is used for analyzing and summarizing the clinical data in the repository of an EMR system. However, it can also be used for clinical terms; the NANDA Taxonomy is an example that can be used for the clinical terms in a list of nursing diagnosis in the nursing record.

Based on the above information model, 69 nursing forms from 62 nursing units were analyzed to identify the type of information being documented. The structured forms were analyzed using a data matrix based on data items. We found many similarities and a few difference between the forms. For example, seven different types of forms were used to record admission nursing assessments: basic demographics (e.g., name, age, sex, ID number, and address), health history, family history, admission information, physical assessment, and admission education were recorded in all forms; whereas birth history, immunization schedule, obstetric history, and psychological history were only included in some of the forms. We derived an interface with eight data views encapsulating the existing 69 nursing forms by considering these similarities and differences (Table 1).

### 2.2. Object-oriented system design

In software development, there are several ways to develop a model. The two most common approaches are from an algorithmic perspective and from an object-oriented perspective. The traditional view takes an algorithmic approach, in which the main building block is the procedure or function. This view leads the developer to focus on issues of control and the decomposition of larger algorithms into smaller ones. However, changes in requirements and system growth make it very hard to maintain systems built with an algorithmic focus.

The contemporary view of software development takes an object-oriented perspective. In this approach, the main building block is the object or class. An object is generally drawn from the solution space, and a class is a description of a set of common objects. Every object is characterized by its identity, state (i.e., there is normally some data associated with it), and behavior. This approach has become mainstream simply because it has proven effective in building systems in all sorts of problem domains and encompassing all degrees of size and complexity [11].

In traditional health information system design, clinical data and the rules for manipulating the data are built within the applications. As the same set of data might need to be shared by clinicians with various professional orientations, different software modules of the system were created to access and manipulate the same data [12,13]. Often multi-

<table>
<thead>
<tr>
<th>Data view</th>
<th>Information content</th>
<th>Target nursing unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admission nursing assessment</td>
<td>Demographics, admission information, history (health, illness, family, obstetric, menstruation, and immunization), physical assessment, and education</td>
<td>Inpatient units</td>
</tr>
<tr>
<td>Graphic record</td>
<td>Vital signs, admission or post-operation day, bowel movements, diet, activity, and input and output</td>
<td>Inpatient units</td>
</tr>
<tr>
<td>Flow sheet</td>
<td>Vital signs, admission or post-operation day, diet, position, input and output, medication, ventilator settings, signs and symptoms of respiration, gastrointestinal tract, wounds, consciousness, and skin integument, laboratory, and imaging tests</td>
<td>Intensive care units: MICU, NICU, SICU, and RICU</td>
</tr>
<tr>
<td>Nursing notes</td>
<td>Nursing process</td>
<td>Inpatient and outpatient units</td>
</tr>
<tr>
<td>Preoperative check list</td>
<td>Patient ID, nursing activities, and education</td>
<td>Surgical, and obstetric and gynecologic units</td>
</tr>
<tr>
<td>Nursing discharge plan</td>
<td>Discharge care plan, medication education, and future appointments</td>
<td>Inpatient units</td>
</tr>
<tr>
<td>Operating room nursing record</td>
<td>Operating room staff, procedures, operating time, anesthesia, materials used, and medication</td>
<td>Operating room</td>
</tr>
<tr>
<td>Nursing order check list</td>
<td>Nursing orders</td>
<td>Inpatient units</td>
</tr>
</tbody>
</table>

MICU, NICU, SICU, and RICU stand for medical intensive care unit, neonatal intensive care unit, surgical intensive care unit, and respiratory intensive care unit, respectively.
ple copies of the same data are created for convenience, or as a result of undisciplined programming practices. When data is manipulated by different program modules operating with different business process, inconsistencies in or corruption of the data are not uncommon. The level of program complexity and the extra efforts required to maintain data consistency inevitably result in high costs [14].

The above factors mean that the data must be clearly separated from the applications that manipulate them. This is achieved by allocating the data to a specific class of data objects that protects it, and the application of the data abstraction (encapsulating and information hiding) principle. This approach ensures the entrusted data as well as an object’s behaviors are hidden from the users and other objects. Objects use messages (commands) to invoke methods (functions) to perform various operations that may produce a change in the object’s state (attributes or data values). Only the methods of an object have access to the members of its data set. Limiting the access to and manipulation of data through the ‘authorized’ object and its methods ensures their accuracy and consistency. The properties of data abstraction, inheritance, and polymorphism, and the ability of objects to effectively model the complexity of the real world make the object-oriented technique well suited to the design and development of complex applications [15]. These advantages of object-oriented technique prompted us to adopt this technique in the present study.

3. Methods

3.1. The Unified Modeling Language and the rational unified process

Visualizing, specifying, constructing, and documenting a software system requires the system to be viewed from several perspectives. Different stakeholders – nurses, nurse managers, analysts, developers, system integrators, and project managers – each bring different agendas to a project, and each looks at the ENRS in different ways at different times over the life of the system. To keep the analysis, design, implementation, and maintenance of an ENRS manageable, the system as well as its underlying concepts has to be formalized and systematized using modeling techniques, in which basic components and concepts can be defined for ease of use and to enable the formation of a comprehensive real-world system. For optimized solutions, the system should be viewed from enterprise, information, computational, engineering, and technology perspectives. The availability of such views facilitates the involvement of the different stakeholders and ensures the implementation of the needs of the users. This study defined such models and employed methodologies such as the Unified Modeling Language (UML) so as to appropriately specify the system components and their behavior.

The UML was selected in 1997 as a standard notation by the Object Management Group out of the various methodologies related to object-oriented technology [16–18]. Booch, Rumbaugh, and Jacobson initiated the UML, and proposed a rational unified process (RUP) as a development process that could take full advantage of the UML. They suggested that the UML is not a standard for the development process, but a standard for the artifacts of development (semantic models, syntactic notation, and diagrams). The RUP captures the best practices in modern software development in a form that can be adapted to a wide range of projects and organizations.

The above-mentioned features lead us to adopt the RUP as our project methodology. The RUP has four phases: inception, elaboration, construction, and transition. During elaboration, it is necessary to acquire a good grasp of the requirements and establish an architectural baseline as a development standard for the construction phase. During construction, the product is built up – often in several iterations – to the beta release. In the transition phase, the product is transitioned to the end user and the project focus moves to end-user training, installation, and support. The RUP is a model-driven approach, and several models are needed to fully describe the evolving system. The scope of this paper is limited to two iterations of the elaboration phase (Fig. 2). Therefore, we used use case models to identify what the system is supposed to do and the system environment. We then identified the class diagrams as a design model describing the realization of the use cases.

For the two models of use case and design, four artifacts were used: use case diagram, use case description, activity diagram, and class diagram. For the effective application of the RUP and an accurate extraction of requirements, a modeling team was formed comprising a project manager, systems analysts, user representatives, and nursing informaticists. The project manager was responsible for identifying the data flow and interface problems between the ENRS and other relevant systems. The system analysts and nursing informaticists identified user requirements through regular meetings with user representatives. User representatives consisted of nine nurse managers from six major nursing units: internal medicine, general surgery, intensive care unit, gynecology, pediatrics, and special surgery; they identified the user requirements in consultation with the authors.

3.2. Modeling artifacts and specification

We selected a scenario approach to extract user requirements. We wrote a scenario designed to highlight the functional area of focus (nursing note taking) within the specified operational environment (nurse station) and time frame (recently). After obtaining approval for the scenario, we drafted a scenario story based on an adaptation of one of the many such stories available. We defined a scenario story as a probable sequence of activities within our scenario. An excerpt of our scenario story for the above scenario is provided below. Our scenario story consisted of short structured sentences. The structure of our paragraphs centered on the actions of a nurse over a short time period. The nurse’s actions within each paragraph were always directed toward a single purpose. At the scenario story matured, we drew a scenario activity diagram that depicted the sequence of activities in the scenario story. Activities that resulted in information exchange were identified and drawn, and story actions were mixed with these information exchanges as necessary to provide context. The principle objective of the scenario activity diagram was to depict
instances of information exchange to aid in the identification of potential use cases.

We formulated use cases using these scenarios, with the use cases for a given scenario defined as a use case set. We recognized that use case sets for a given scenario varied across operational environments and time. Operational environments could include such entities as inpatient and ambulatory departments. A use case describing a nurse’s use of a computer could involve the use of a handheld computer at the bedside of a patient. Use case sets for a given scenario also change with time, such as an increasing trend toward voice data entry as the technology emerges. The use case set reported here corresponded to a tertiary teaching hospital during 2003.

After formulating use cases, we identified classes and their relationships (which is one of the cornerstones of the object-oriented approach). Here we report on the class diagrams, which are divided into internal and external views. The external view contains external elements that correspond to the people and things engaged in information exchange outside the ENRS, whereas the internal view contains only elements from the ENRS. An object-oriented methodology expert reviewed modeling products and provided progressive feedback to the research team. This approach helped the team to look at the real world with object concepts and to describe the system whilst following the RUP.

4. Results

4.1. Use case view

The use case view describes the behavior of the ENRS as seen by a nurse, a nurse manager, and a physician. The static aspects of this view were captured in a use case diagram (Fig. 3).

The use case diagram comprised eight use cases addressing record management and six use cases addressing nursing terminology management. The part devoted to the management of nursing terminology was specialized to the ICNP Term Management use case, Statement Management use case, and three other use cases supporting functions of terminology management. Physician, Nurse, and Nursing Term Manager were identified as the actors that use these use cases. The Physician is an actor who also represents other healthcare professionals that need to refer to nursing documents, such as nutritionists, pharmacists, radiation therapists, and staff of the insurance department. The Nurse (including the nurse manager) is an actor who participates in writing nursing documents, and supervises them for service quality assurance. The Nursing Term Manager is an actor that takes charge of terminology management, including the ICNP concepts and controlled pre-coordinated statements.

The dynamic aspects of use case view were captured in an activity diagram (as shown in Fig. 4) that describes the flow between activities within the ENRS. The overall task flow of the ENRS was identified in the activity diagram. The Nursing Term Manager is in charge of creating, updating, and maintaining nursing terminology, and controlling the pre-coordinated statements that the nurse uses in the data input process. The administrative terms identified by the Nursing Term Manager are used in the analysis of nursing records for the various purposes of data aggregation. For example, the chief nurse manager of the internal medicine department may want to retrieve the nursing diagnosis and the nursing activity lists identified in patients admitted to the oncology nursing unit during specified periods. He or she will use such information to understand trends in nursing problems or to distribute...
**Fig. 3 – Use case diagram of the ENRS.**
Fig. 4 – Activity diagram of the ENRS.

nursing resources during subsequent time periods. The ENRS retrieves the nursing problems and activities under the given conditions, and returns the result in abstracted forms using administrative terms. It is a common task for managers to use these aggregating functions. The role of the Physician is simply retrieving and inquiring functions through the various user interface displays.

Use case specifications were documented from scenario stories and identified use case properties. Use case specifications include the name, a brief description, the event flows, alternative flows, special requirements, and the pre- and postconditions. Each flow of events was described in narrative form. Fig. 5 shows a part of specification for the Nursing Notes use case. In this specification, the event flows comprise the normal data input, update, and delete scenario, while alternative flows contain exceptional scenarios including incomplete data input, data errors, and network errors. The special requirements address items such as authorizations and logging events of deletions and modifications to the statements in the database. Also constraints such as those listed below (an example of a Nursing Notes use case description) were identified as pre- and postconditions:

- The authorization required to add, modify, or delete a record.
- The system logs for tracing changes to a record.
- The requirement for a digital signature for legal reasons.

4.2. Design view

The design view supports the functional requirements of the system, which are the services that the system should provide to its end users. With the UML, the aspects of this view were captured in electronic nursing record class diagrams. The use cases of the ENRS can be divided functionally into two packages, Nursing Records and Nursing Term Management, where each package includes a Nursing Records class diagram and a Nursing Term Management class diagram.

Fig. 6 shows the class diagram for four types of nursing data views: ‘admission nursing assessment’, ‘graphic record’, ‘nursing notes’, and ‘flow sheet’. This diagram consists of seven entity classes, four boundary classes, four control classes, and their interrelationships. Eight entity classes that are applicable to each nursing data view are also included in this diagram. The classes used to store patient data were omitted from Fig. 6 in order to decrease the complexity of the figure. In this diagram, entity, boundary, and control classes are used for a database table schema, user interface, and data processing, respectively. Each boundary class requests specific operations related to control classes, and then each control class manipulates the data received from the related entity classes.

The four use cases correspond to the classes of Initial Assessment, Vital_sign_Sheet, Nursing_Notes, and ICU_Nursing_Record, respectively, in the class diagram. The Initial Assessment class is representative for the other three use cases of ‘preoper-
1. Maintaining Nursing Notes

1.1. Brief Description

This use case allows the nurse to maintain nursing notes for each patient in the ENRS, including adding, modifying, or deleting single episodes of the "Nursing Notes" use case.

1.2. Flow of Events

1.2.1. Basic Flow

This use case starts when the nurse wishes to add, change, and/or delete one record of the "Nursing Notes" case in the system.

1. The system requests that the nurse specifies the function he or she would like to perform (add a new record, modify a record, or delete a record).

2. Once the nurse provides the requested information, one of the following subflows is executed:
   - If the nurse selected "add a new record", the Add a New Record subflow is executed.
   - If the nurse selected "modify a record ", the Modify a Record subflow is executed.
   - If the nurse selected "delete a record ", the Delete a Record subflow is executed.

1.2.1.1. Add a New Record

The system requests that the nurse enter the "Record Time!", which comprises the year, month, day, hour, and minute.

1. Once the nurse provides the requested information, the system generates and assigns a unique ID to the record. The system opens a new input window with the navigation tree of a controlled statement, and is ready for input.

2. The system registers the ID of a controlled statement that the nurse selected from the statement navigation window.

3. The system provides the attribute list of the registered statement.

4. The nurse enters the values of the attribute list.

5. The nurse may repeat steps 3 to 5 for different statements.

6. The system registers the statements in the order of entry as a record unit.

7. The nurse notifies the system that the input is completed.

8. The system waits for the signal from the nurse.

1.2.1.2. Modify a Record

1. The system requests that the nurse select the record.

2. When the nurse selects the record, the system retrieves and displays it on the window for input.

3. The nurse makes the desired changes to the record, including any of the information specified in the Add a New Record subflow.

4. Once the nurse updates the necessary information, the system updates the record.

Fig. 5 – Partial example of a Nursing Notes use case description.

ative check list", 'nursing discharge plan', and 'operating room nursing record', because the classes for the three use cases are driven dynamically from the class of Nursing_Record_Items in the same way as for the Initial_Assessment class. However, the classes for 'graphic record' and 'flow sheet' have fixed data items and are separated into the Nursing_Record_Item_Selection, Vital_Sign_Sheet, and ICU_Nursing_Record classes. The 'nursing notes' case uses the Statement class directly. The class for a 'nursing order check list' is not shown in this diagram because its data items come from the physician order contained in a physician order entry system that is external to the ENRS.

In the notation of the UML, the rectangles of Fig. 6 provide information about each class. The top tier in each rectangle contains the name of the class, and the middle tier contains the member items identified in the use cases. Member items are not synonymous with the data elements of a database schema–data elements are more detailed and discrete than member items in this project.

The class diagram of Fig. 7 consists of six entity classes, three boundary classes, four control classes, and their inter-relationships. The ICNP_Terminology and Statement classes refer to the ICNP beta version and controlled statements populated from the ICNP, respectively. The ICNP_Attributes class is introduced to increase the expression granularity of a controlled statement, and is predefined as properties for each concept. For instance, the concept of 'body temperature' could have the value of body temperature and the site of measuring as its attributes. These attributes are used when a controlled state-
Fig. 6 – Class diagram of the Nursing Records package.

Fig. 7 – Class diagram of the Nursing Term Management package.
The current widespread use of SNOMED CT clinical terms in electronic medical records marks a shift in emphasis away from the notion of a mere ‘reference terminology’ towards a terminology system for direct use in clinical applications [19]. The use of the ICNP marks the same type of shift in nursing. However, there are concerns that the size and inherent complexity of this emerging combinatorial nursing terminology system make its direct application awkward. In order to ameliorate this awkwardness, the combinatorial terminology has been mapped ‘behind the scenes’ [20,21]. However, it is not clear how the combinatorial terminology can be applied to a real system in order to realize its benefits with usability.

To address this issue, we systematically approached the analysis and design requirements of a terminology-based ENRS that was implemented in May 2003 at Bundang Seoul National University Hospital, Korea. We reviewed previous studies relevant to electronic nursing records in the context of an EMR. A few studies have considered the modeling issues of a clinical information system [14], electronic health records as an integrated platform [22], and the process of undertaking activities in a hospital [23]. These studies were concerned with the business processes and system integration at the national or enterprise level, whereas our primary concern was how to express the requirements considering the characteristics of nursing records into the EMR context.

Nursing records traditionally contain documentation in a narrative form, which is easier to simply transfer to a computer screen in the form of free text. However, when using free text it is hard to apply standard terminology and obtain data reusability. To overcome these problems, our analysis and design effort focused on structuring nursing content and the application of the ICNP as a nursing-specific terminology.

In this study, we considered a broad overview of the ICNP-based ENRS. Applying the dynamic data-view approach at the design level lead to the nursing documentation being encapsulated as eight data views in which the ICNP was used to define the clinical terminology. This resulted in all the patient nursing data being accessed systematically with the ICNP concepts.

Egyhazy et al. [24], Johnson [25], and Gu et al. [26] have investigated the modeling methodology. Egyhazy et al. proposed a methodology for modeling computer-based patient records in a military health services system, and highlighted the usefulness of an object-oriented analysis and design; Johnson modeled communication data using a conventional approach; and Gu et al. applied an object-oriented database representation to controlled medical terminology management. The latter two studies focused on data modeling rather than system behavior, which was designed separately with data. In contrast, we attempted to obtain an understanding of both the static and dynamic aspects of the target system, by regarding them simultaneously at the modeling level. The object-oriented approach is now being widely used due to the current trend of increasing complexity of hospital information systems associated with the increasing need for integrated hospital information systems, intelligent healthcare system analysis and decision support systems.

We initially intended to take advantage of being able to design robust, reliable, reusable, and easily maintainable clinical systems using object-oriented techniques, but our unfamiliarity with these techniques prompted us to begin by

**Table 2 – Example of recording a patient’s level of consciousness based on the design and implementation levels of the model**

<table>
<thead>
<tr>
<th>Design level (entity class)</th>
<th>Implementation level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Database table</td>
<td>Tuples of field name and value</td>
</tr>
<tr>
<td><strong>Nursing_Record_Item Statement</strong></td>
<td>(Item_ID, 1234), (Item, ‘consciousness’), (Statement_ID, 5678), ...</td>
</tr>
<tr>
<td><strong>ICNP_Statement_Map</strong></td>
<td>(ICNP_ID, 1111), (Statement_ID, 5678), ...</td>
</tr>
<tr>
<td><strong>ICNP_Terminology</strong></td>
<td>(ICNP_ID, 1111), (English_Name, ‘observing’), ...</td>
</tr>
<tr>
<td><strong>ICNP_Attributes</strong></td>
<td>(ICNP_ID, 1111), (Attribute_Name, ‘Level’), ...</td>
</tr>
<tr>
<td><strong>Admission_Nursing_Assessment</strong></td>
<td>(Patient_ID, 888888), (Item_ID, 1234), (Statement_ID, 5678), ...</td>
</tr>
</tbody>
</table>

* Indicates entries with two corresponding records. The field name of each unique ID is assigned randomly in this example.
considering scenarios, for which we followed the formal RUP methodology with artifacts. This approach helped our team to look at the real world with object concepts and to describe the system in a consistent manner. Also, this approach (specifically the use of use case descriptions) made it easier to communicate with users who had little experience in the use of an ENRS. We showed and explained the simulations of the interactions described in the use case descriptions to the users so that they could understand how the system behaves and what it looks like, which encouraged their active participation and feedback. The requirements extracted were transferred clearly to system designers and development personnel in our team.

We encountered a few problems during the analysis and design of the system. For example, there was considerable debate on whether free-text input should be permitted in the nursing notes use case, which related to how strictly the use of a controlled vocabulary is enforced. Another issue was ambiguity in the information model adopted, which was related to the application of coded nursing data. It is expected that nursing data mapped with the ICNP concepts will be easily retrievable for multiple purposes such as supporting clinical decisions and comparing the effects of different nursing activities. However, whilst this type of application is a conceptual one with potential opportunities for informatics to contribute to the nursing domain, how to instigate this needs careful consideration. For other issues such as data access authorization by different user groups (nurse students, managers, medical staff, pharmacy staff, nutritionists, and physical therapists), the user identification method, and co-sign between care team members were raised to be considered.

The design process should consider that data objects can come from continuous monitoring equipment in intensive care units, for example. Clinicians want to examine these data along with other information in the ‘flow sheet’ data view, which requires those data to be displayed into single screen at time intervals defined by users. Medication data have also a similar design requirement. In the unit-dose system, some medication data come into an ENRS from a bar code system, which required appropriate interfaces with the related systems.

This study allowed us to clearly identify the structural and behavioral states of our terminology-based ENRS. In particular, the use of scenarios and use cases greatly helped in extracting user requirements, and in understanding the IT domain including the five artifacts. Additionally, this approach provides a systematic method for the model to evolve continuously with consistent concepts, which is very important for a terminology-based system due to the continuing evolution of nursing terminology. In addition, the models can be reused in further system requirements such as developing an enterprise data warehouse or integrating the ICNP with other healthcare terminologies such as SNOMED®.

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Summary points

What was known on this topic before the study?

• It is necessary to use a standard terminology in the implementation of an electronic nursing record system.
• The ICNP was developed by the ICN as a standard nursing terminology to exchange nursing data and compare nursing services.
• Nursing data are traditionally recorded in both structured and free-text formats, which make it difficult to implement an ICNP-based ENRS.

What this study has added to our knowledge?

• We have demonstrated the usefulness of using a systematic approach (use of OOAD, UML, and RUP) in the implementation of an ENRS.
• We have described how we applied the ICNP to all nursing documentation.
• We have described how to overcome the problems encountered in this field.

References


