



Design of databases

Conceptual design



Conceptual design (1/2)

- Database design stages
- Design example: problem specifics
- Design example: main concepts
- Design example: model refinement (I)
- Design example: model refinement (II)
- Design example: model refinement (III)

Conceptual Design (2/2)

- Design example: representation of time (I)
- Design example: representation of time (II)
- Design example: representation of time (III)



Conceptual design

Database design stages

Database design stages

**Application
requirements**



Database design stages

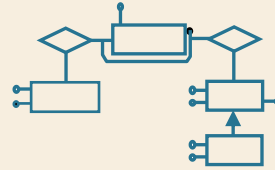
Application requirements



Conceptual design



Conceptual scheme



Database design stages

Application requirements



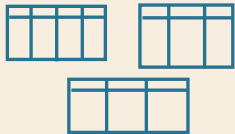
Conceptual design



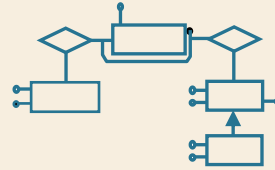
Conceptual scheme



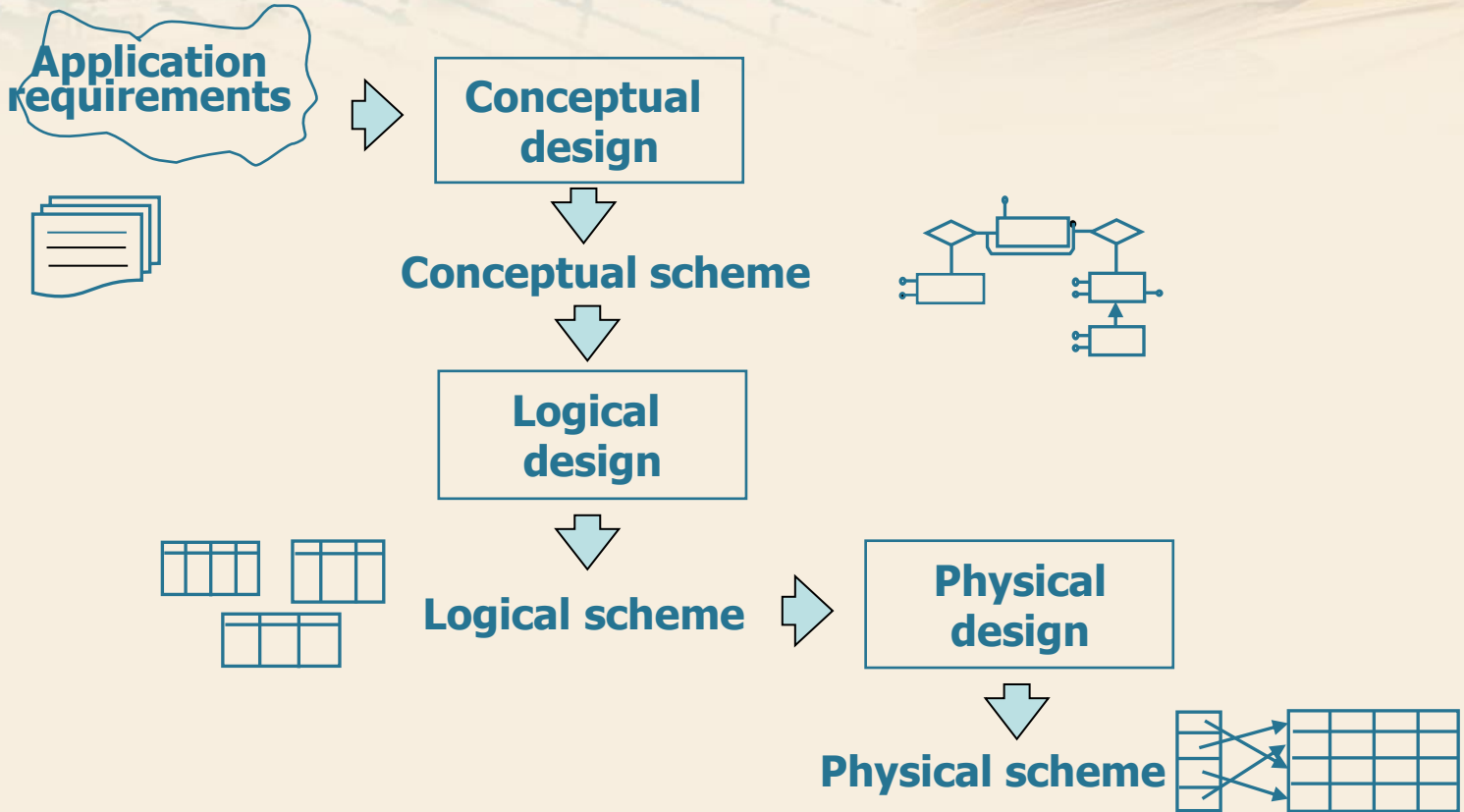
Logical design



Logical scheme



Database design stages



Requirements collection and analysis

➤ Requirements collection

- identification of the problems that the application must solve
- identification of the static and dynamic features of the application

➤ Requirements analysis

- clarification and organization of the specifics

➤ Interconnected and scarcely standardizable activities



Requirements sources

- Application users
 - interviews
 - written documentation
- Existing documentation
 - regulations
 - internal rules
 - forms
- Pre-existing constructions
 - applications to replace or interact with

Requirements collection

- System users play an important role
 - high-level users have a more general view, but they don't know the details
 - different users can provide different information (complementary or contradictory)

Requirements collection

➤ Practical rules

- verify the understanding and consistency of the collected information
- verify also with examples (related to general and borderline cases)
- require definitions and classifications
- identify the essential and marginal aspects
- proceed for subsequent refinements

Requirements analysis

➤ Practical rules

- choose the right abstraction level
- standardize the structure of the sentences
- avoid convoluted sentences
- identify synonyms/homonyms and unify the terms
- make the reference between terms explicit
- build a glossary of terms



Conceptual design

- Various project strategies have been proposed
- The most effective strategy is hybrid
 - the basic concepts are identified (the most relevant entities and relationships)
 - the initial project is progressively refined by adding the attributes, the cardinality of the relationships, the hierarchies, other entities and relationships
- If the problem is highly complex, it can be broken down into subproblems to solve separately and integrate later

Conceptual design: general criteria

- If a concept has significant properties or describes classes of objects with autonomous existence
 - entity
- If a concept has a simple structure and has no relevant properties
 - attribute (possibly multivalued)
- If two or more concepts are related
 - relation
- If a concept is a particular case of another one
 - hierarchy

Quality of a conceptual scheme

➤ Correctness

- use of appropriate model constructs
- verification of syntactic and semantic errors

➤ Completeness

- representation of all the concepts of interest

➤ Minimality

- every specifications is represented only once in the scheme
- verification and documentation of any redundancies

➤ Legibility



Conceptual design

Design example: problem specifics



Problem specifics

We want to represent a database for the management of a medical examination booking system within a Local Health Authority (ASL), considering the following information.

Each patient is characterized by health card number, name, surname, address, date of birth, place of birth and age.

ASL hospitals are characterized by a numerical code, name and address.



Problem specifics

Each hospital is divided into departments identified by a unique numeric code and characterized by department name and telephone number.

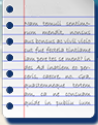
The department staff is identified by a Social Security Number (SSN).

Name, surname and address are also known.

Among the staff, for department doctors the list of specializations achieved is known and for the voluntary staff the name of the association they belong to (if available) is stored.



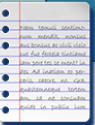
Problem specifics



The medical examinations that can be performed are characterized by a numerical code and a textual description (e.g. radiography, etc.). For specialist examinations, the doctor who carries out the visit and a description of the diet to follow (if necessary) are also stored. The laboratories that perform the **tests** are identified by a unique code within the hospital and they are characterized by the name of the laboratory, the location plan and the room number.



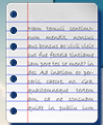
Problem specifics



For each member of the laboratory staff, the days and laboratories in which he works are stored. Pay attention to the fact that during the same day each staff member can work in more than one laboratory.



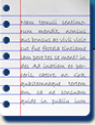
Problem specifics



Each exam requires a reservation. For each exam reservation made by a patient, the date and time of the exam, the laboratory where it is performed, the cost of the ticket and the information about the exam being urgent or not are stored. Please note that each patient can make multiple reservations for the same exam on different dates and the same exam cannot be repeated on the same day by the same patient, even in different laboratories.



Problem specifics



Each doctor can take on different roles during his career (e.g. assistant, head physician, etc.).

We want to keep track of the roles each doctor has taken on during his career and the related time periods (start date, end date).

Keep in mind that each doctor cannot take on more than one role at the same time, but he can take on the same role in different time periods.



Conceptual design

Design example: main concepts

Main concepts identification

- Text analysis to identify the most important concepts
 - the main entities of the ER diagram
 - any links between entities



Patient Concept

Each *patient* is characterized by health card number, name, surname, address, date of birth, place of birth and age.

Patient Concept



Patient



Hospital concept

ASL *hospitals* are characterized by a numeric code, a name and an address.



Hospital concept

Patient

Hospital



Department concept

Each hospital is divided into *departments* identified by a unique numeric code and characterized by the department name and the telephone number.

Department concept

Patient

Hospital

Department



Staff concept

The *department staff* is identified by a Social Security Number (SSN).

Name, surname and address are also known.

Among the staff, for department doctors the list of specializations achieved is known and for the voluntary staff the name of the association they belong to (if available) is stored.

Staff concept

Patient

Staff

Hospital

Department



Exam Concept

The *medical examinations* that can be performed are characterized by a numerical code and a textual description (e.g. radiography, etc.). For specialist examinations, the doctor who carries out the visit and a description of the diet to follow (if necessary) are also stored.

Exam Concept

Patient

Examination

Staff

Hospital

Department



Laboratory concept

The *laboratories* that perform the tests are identified by a unique code within the hospital and are characterized by the name of the laboratory, the location plan and the room number.

Laboratory concept

Patient

Examination

Laboratory

Staff

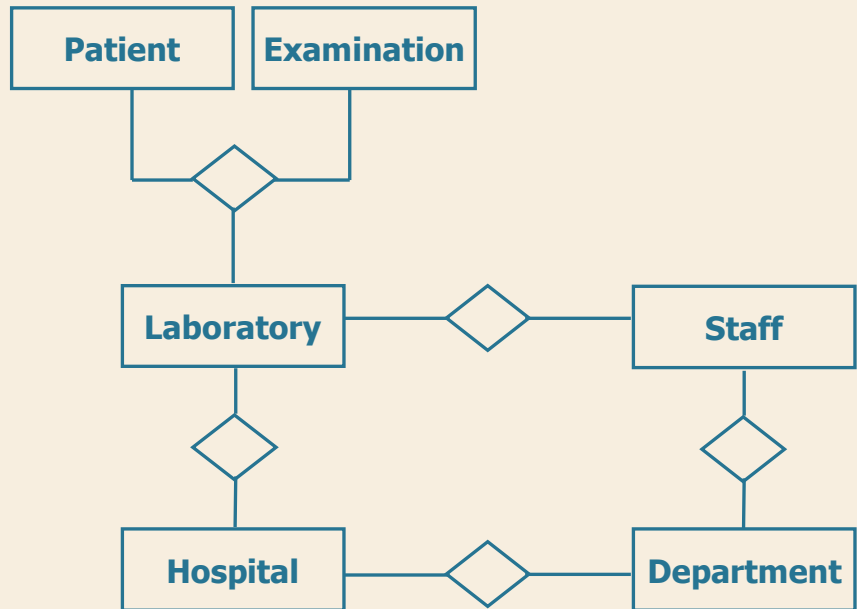
Hospital

Department

Main concepts

➤ Main concepts

- patient
- examination
- laboratory
- hospital
- department
- staff





Conceptual design

Design example: model refinement (I)



Concepts refinement

➤ Refinement of concepts

- introduction of hierarchies
- attributes definition
- characterization of relationships with cardinality

Staff hierarchy

The department staff is identified by a Social Security Number (SSN).

Name, surname and home address are also known.

Among the staff, for *department doctors* the list of specializations achieved is known and for the *voluntary staff* the name of the association they belong to (if available) is stored.

Staff hierarchy

Patient

Examination

Volunteer

Doctor

(p, e)

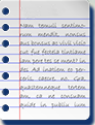
Laboratory

Staff

Hospital

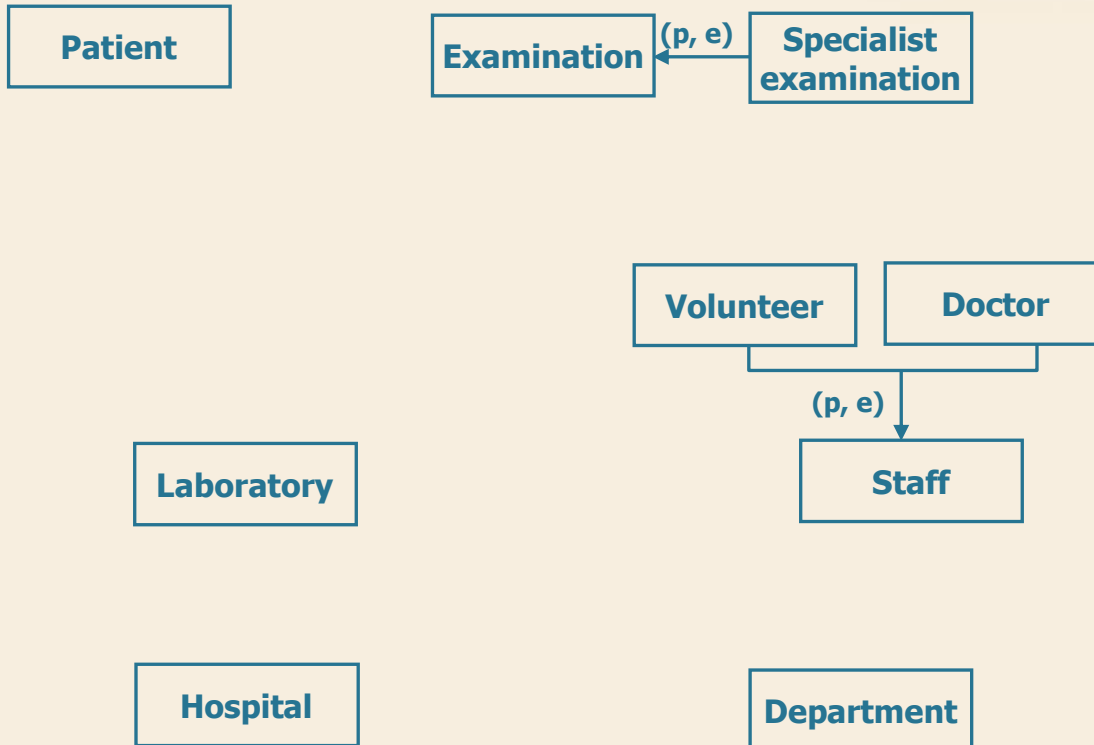
Department

Exam hierarchy



The medical examinations that can be performed are characterized by a numerical code and a textual description (e.g. radiography, etc.). For *specialist examinations*, the doctor who carries out the visit and a description of the diet to follow (if necessary) are also stored.

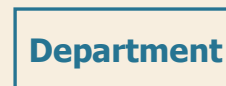
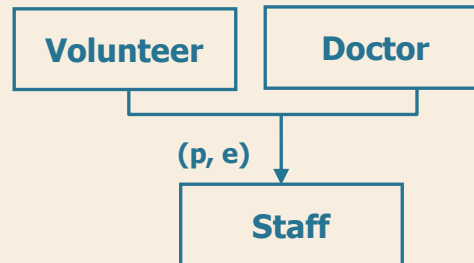
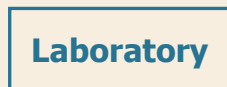
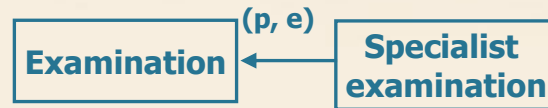
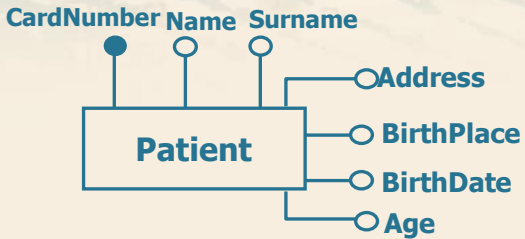
Exam hierarchy



Refinement of the Patient entity

Each patient is characterized by health card number, name, surname, address, date of birth, place of birth and age.

Refinement of the Patient entity

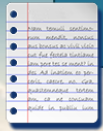


Date of birth and Age Attributes

- The Age attribute is redundant because it can be easily calculated starting from the date of birth (BirthDate)
- This information must be attached to the conceptual model documentation
 - Age derivation rule from BirthDate
 $\text{Age} = \text{Year}(\text{Today}()) - \text{BirthDate}$
- Any elimination of the Age attribute will be evaluated during the simplification phase of the ER scheme

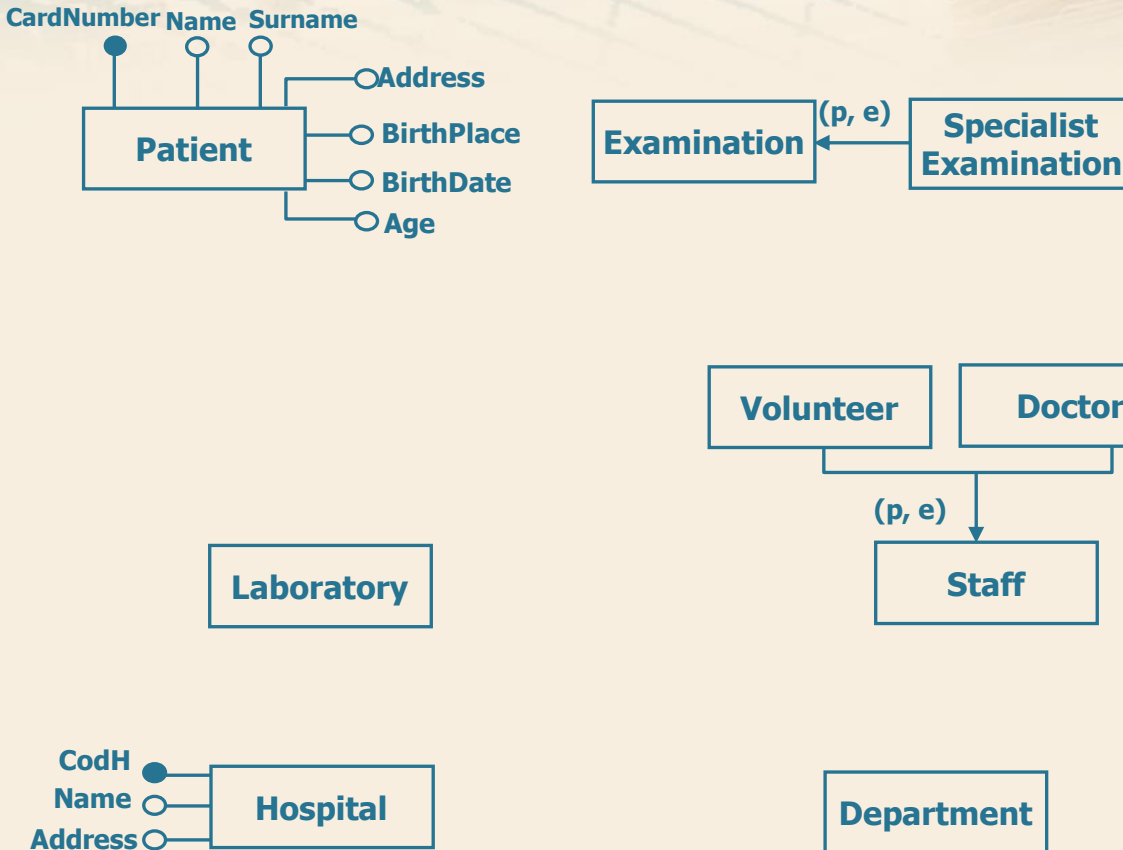


Refinement of the Hospital entity



ASL hospitals are characterized by a numerical code, name and address.

Refinement of the Hospital entity





Conceptual design

Design example: model refinement (II)

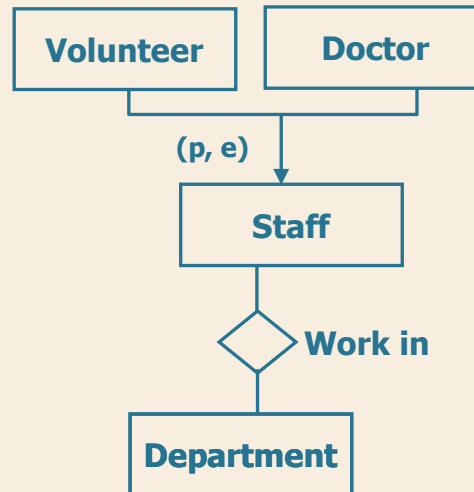
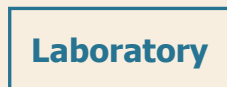
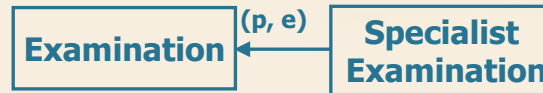
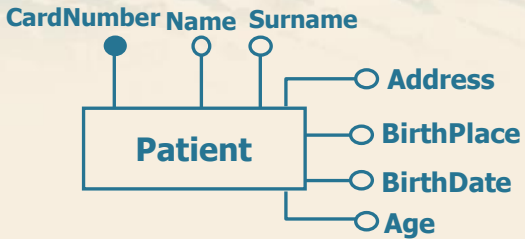
Relationship between Staff and Department

The department staff is identified by a Social Security Number (SSN).

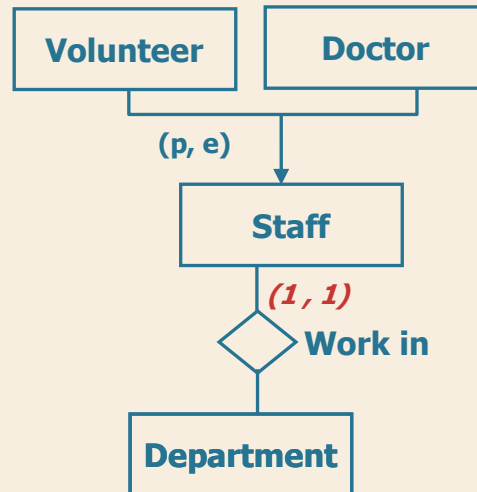
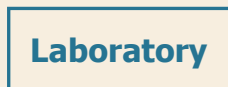
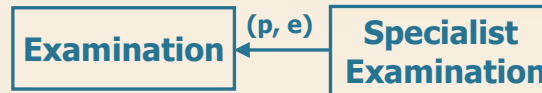
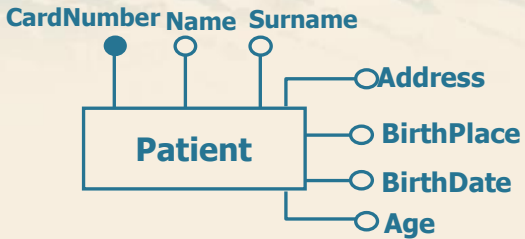
Name, surname and address are also known.

Among the staff, for department doctors the list of specializations achieved is known and for the voluntary staff the name of the association they belong to (if available) is stored.

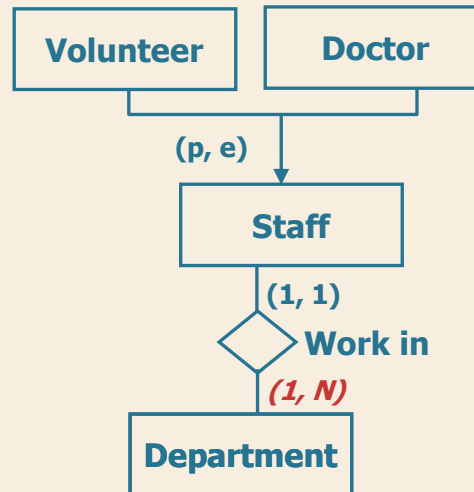
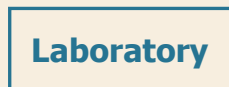
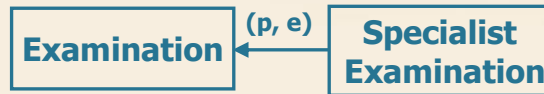
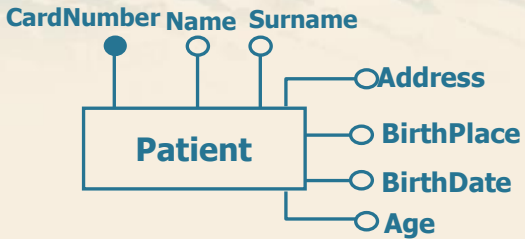
Relationship between Staff and Department



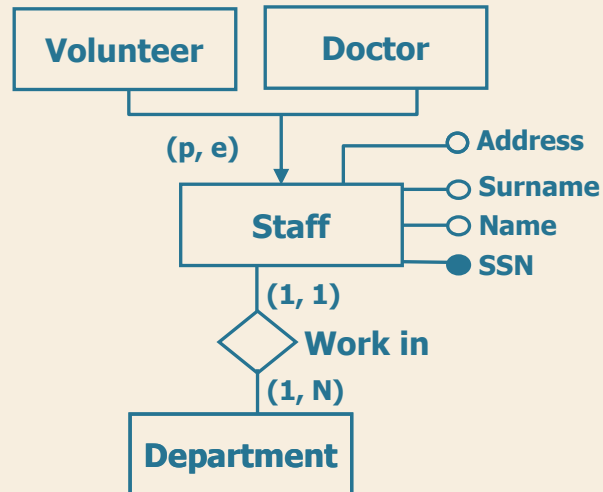
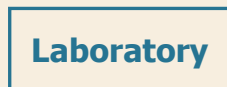
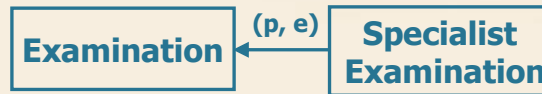
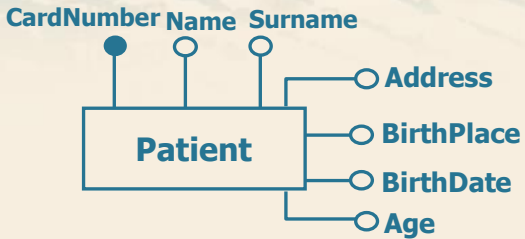
Cardinality of the Work in relationship



Cardinality of the Work in relationship



Refinement of the Staff entity





Refinement of the Medical and Volunteer entities

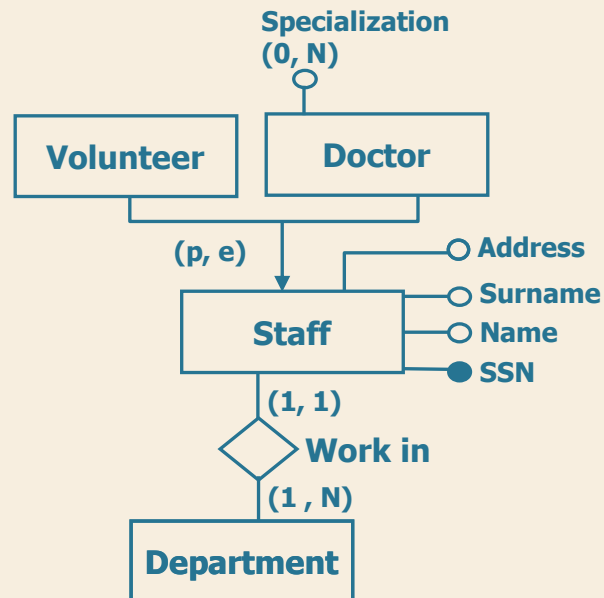
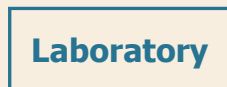
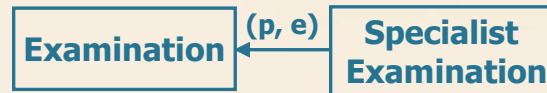
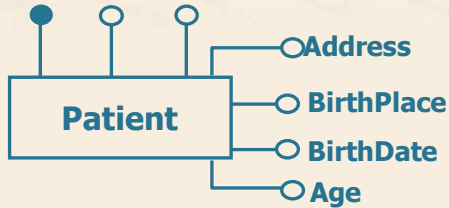
The department staff is identified by a Social Security Number (SSN).

Name, surname and address are also known.

Among the staff, for department doctors the list of specializations achieved is known and for the voluntary staff the name of the association they belong to (if available) is stored.

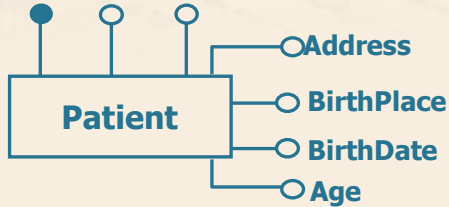
Refinement of the Medical entity

CardNumber Name Surname

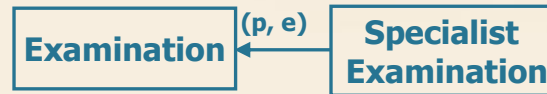


Refinement of the Volunteer entity

CardNumber Name Surname

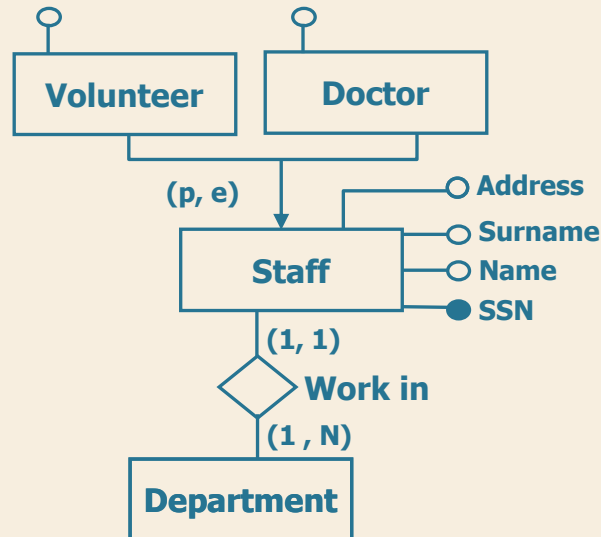


Laboratory



Association
(0, 1)

Specialization
(0, N)

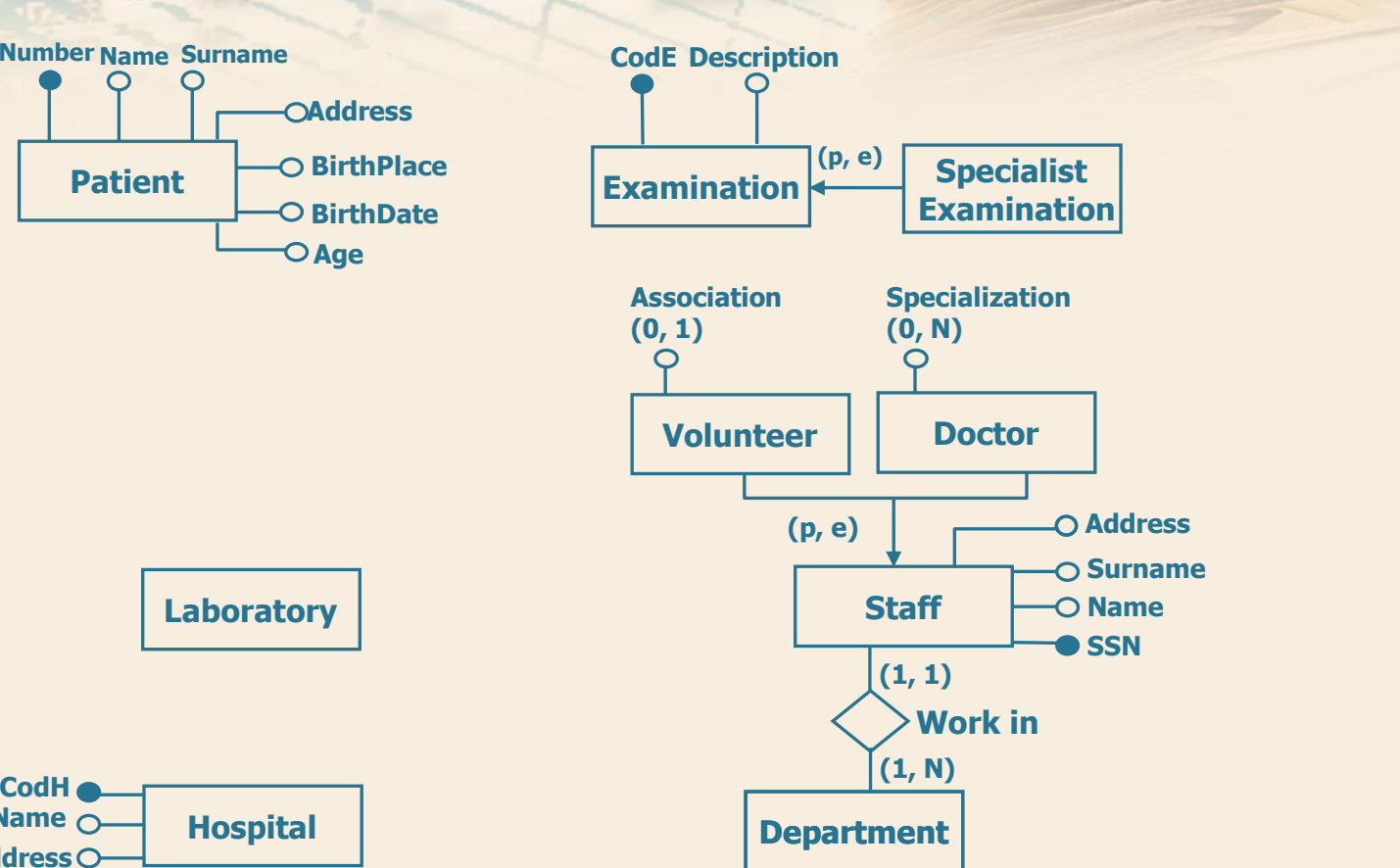


Refinement of the Exam entity

The medical examinations that can be performed are characterized by a numerical code and a textual description (e.g. radiography, etc.).

For specialist examinations, the doctor who carries out the visit and a description of the diet to follow (if necessary) are also stored.

Refinement of the Exam entity

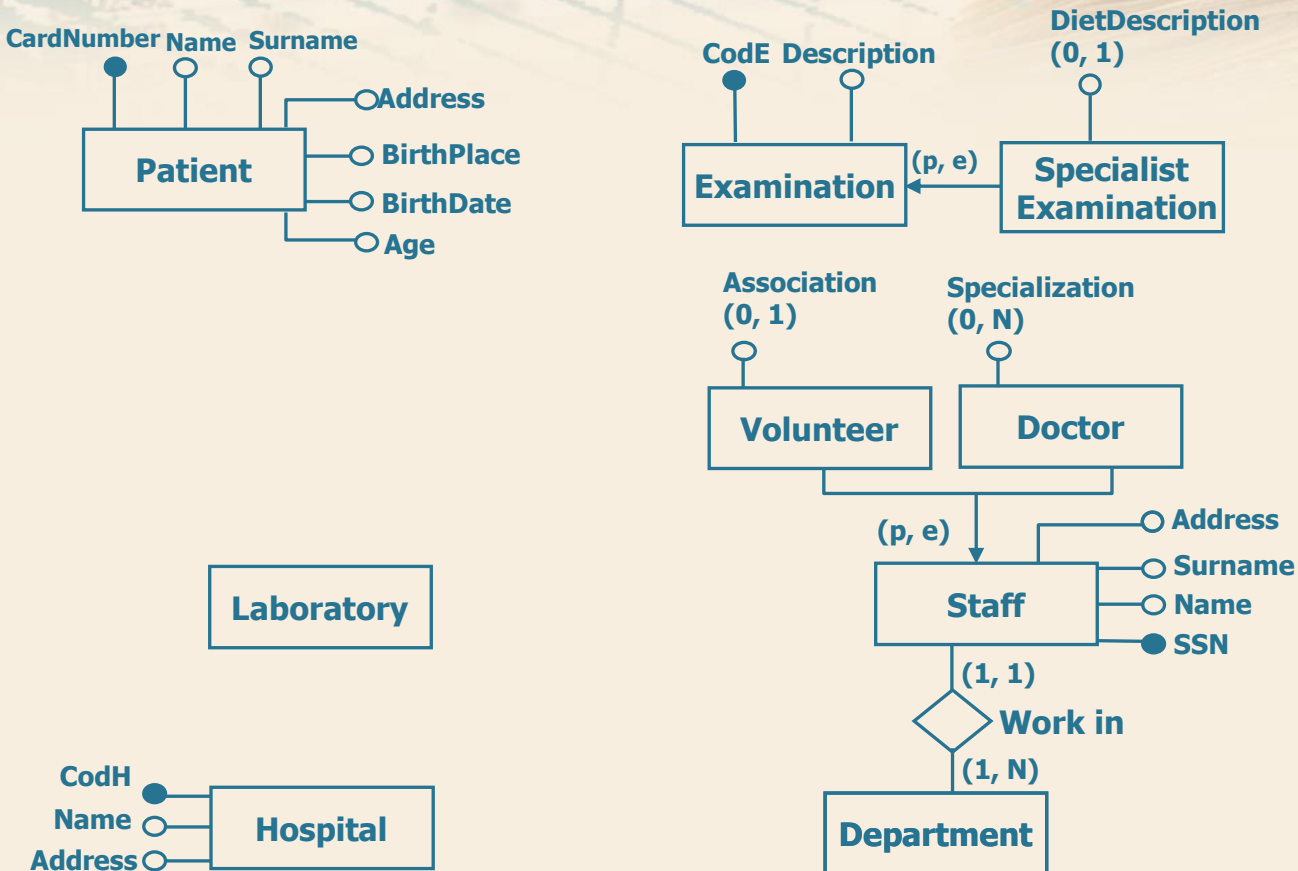


Refinement of the Specialist Examination entity

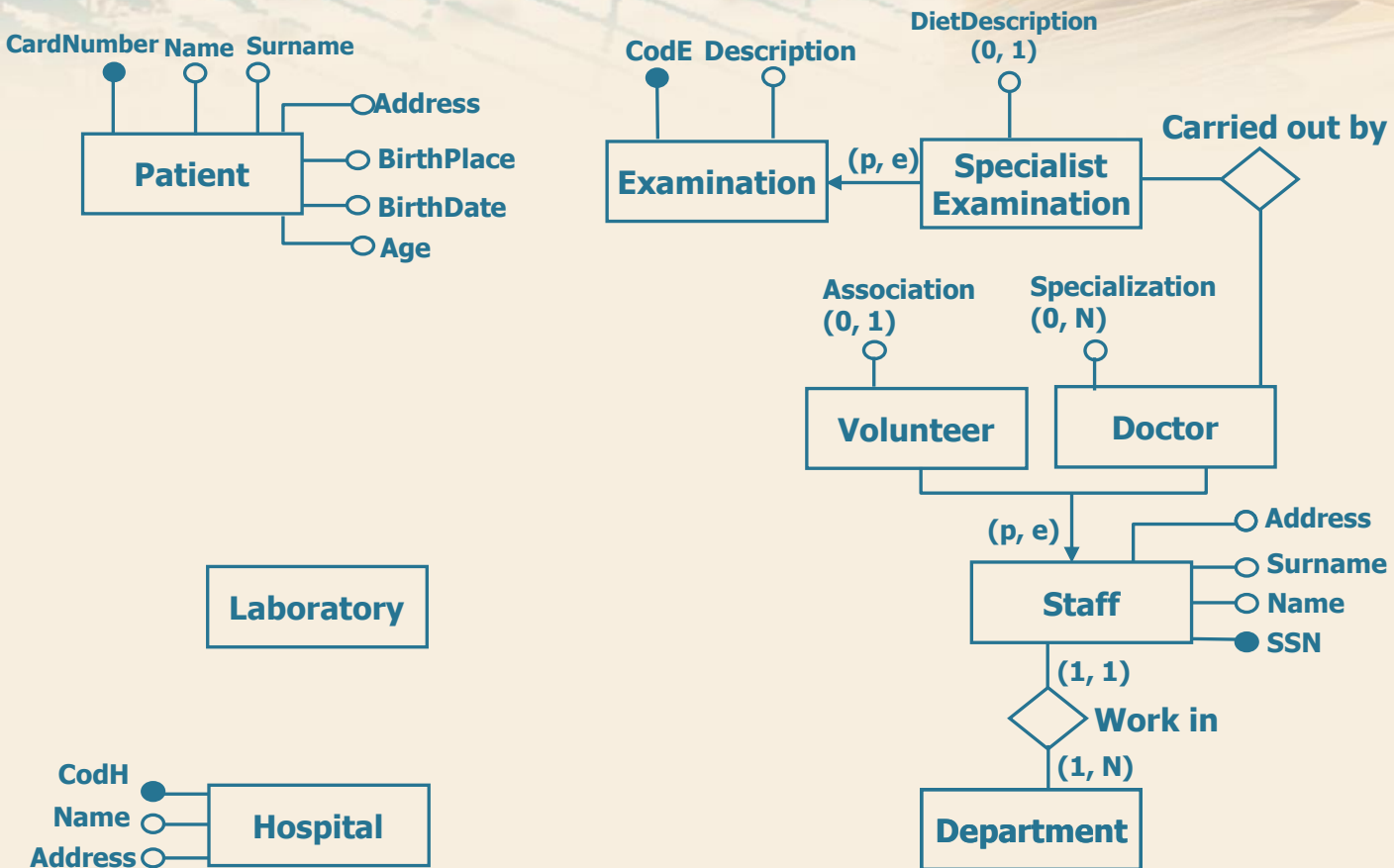
The medical examinations that can be performed are characterized by a numerical code and a textual description (e.g. radiography, etc.).

For specialist examinations, the doctor who carries out the visit and a description of the diet to follow (if necessary) are also stored.

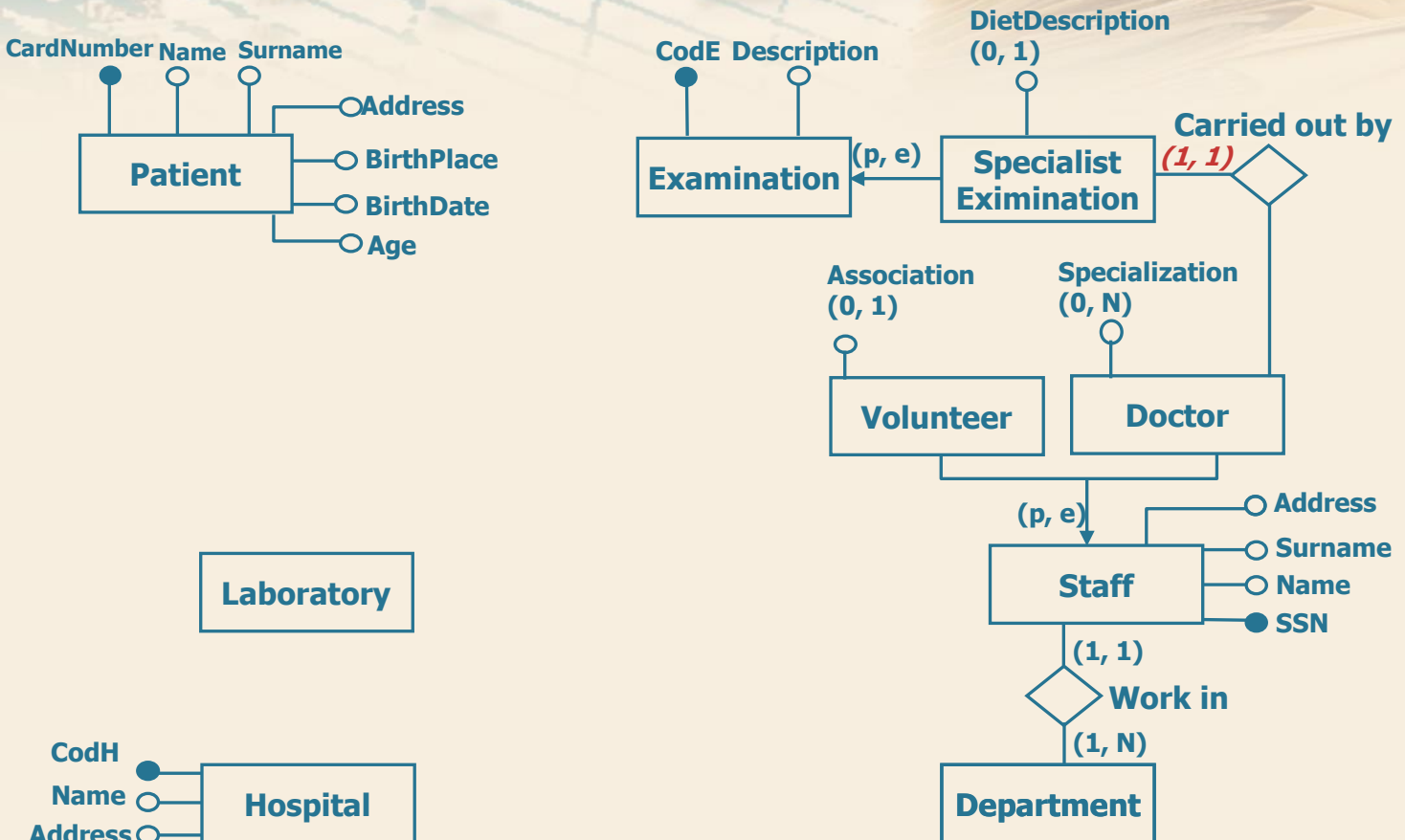
Refinement of the Specialist Examination entity



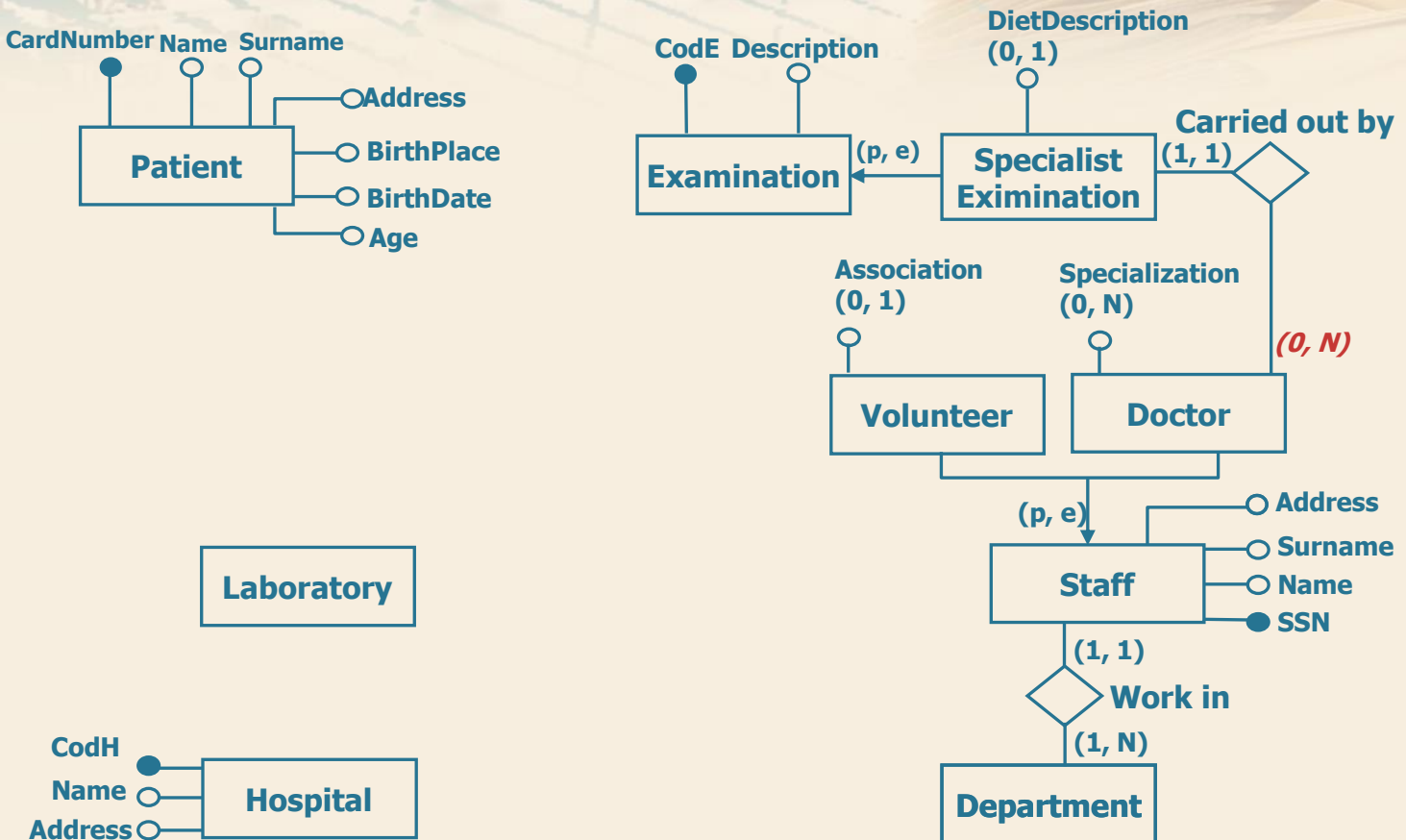
Relationship between Doctor and Specialist Examination



Cardinality of the Carried out by relationship



Cardinality of the Carried out by relationship



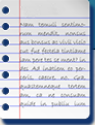


Conceptual design

Design example: model refinement (III)

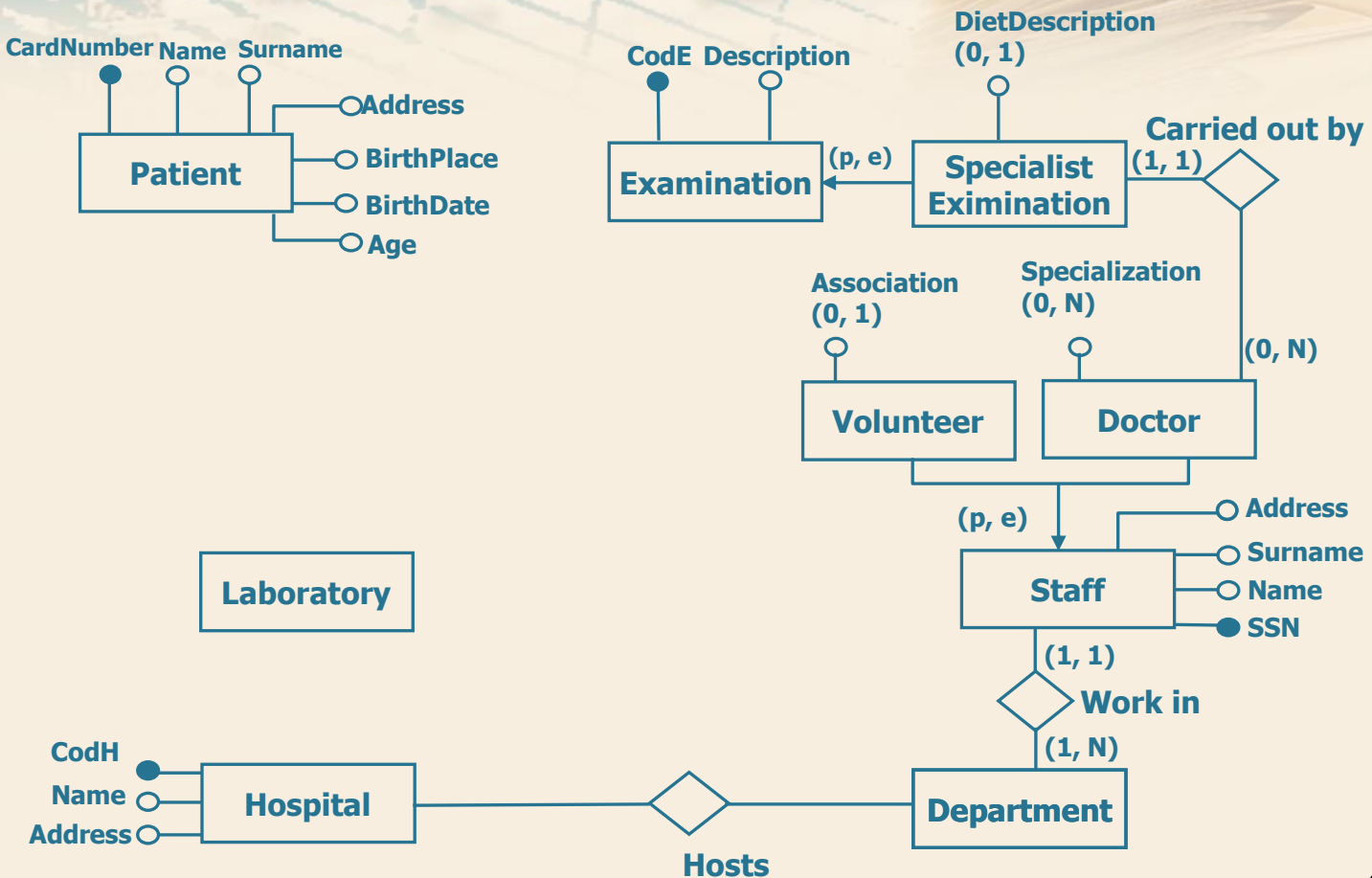


Relationship between Department and Hospital

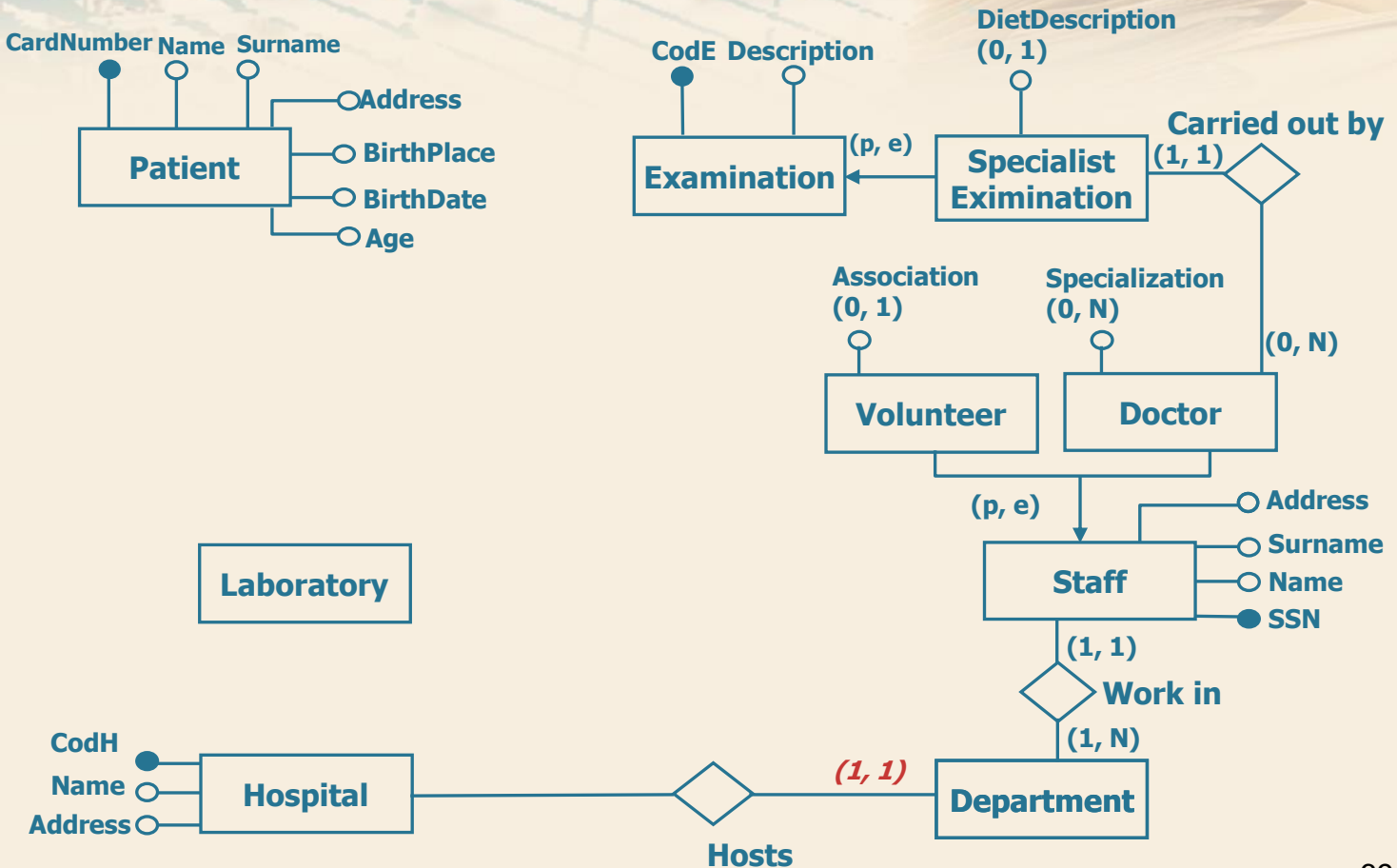


Each hospital is divided into departments identified by a unique numeric code and characterized by the department name and the telephone number.

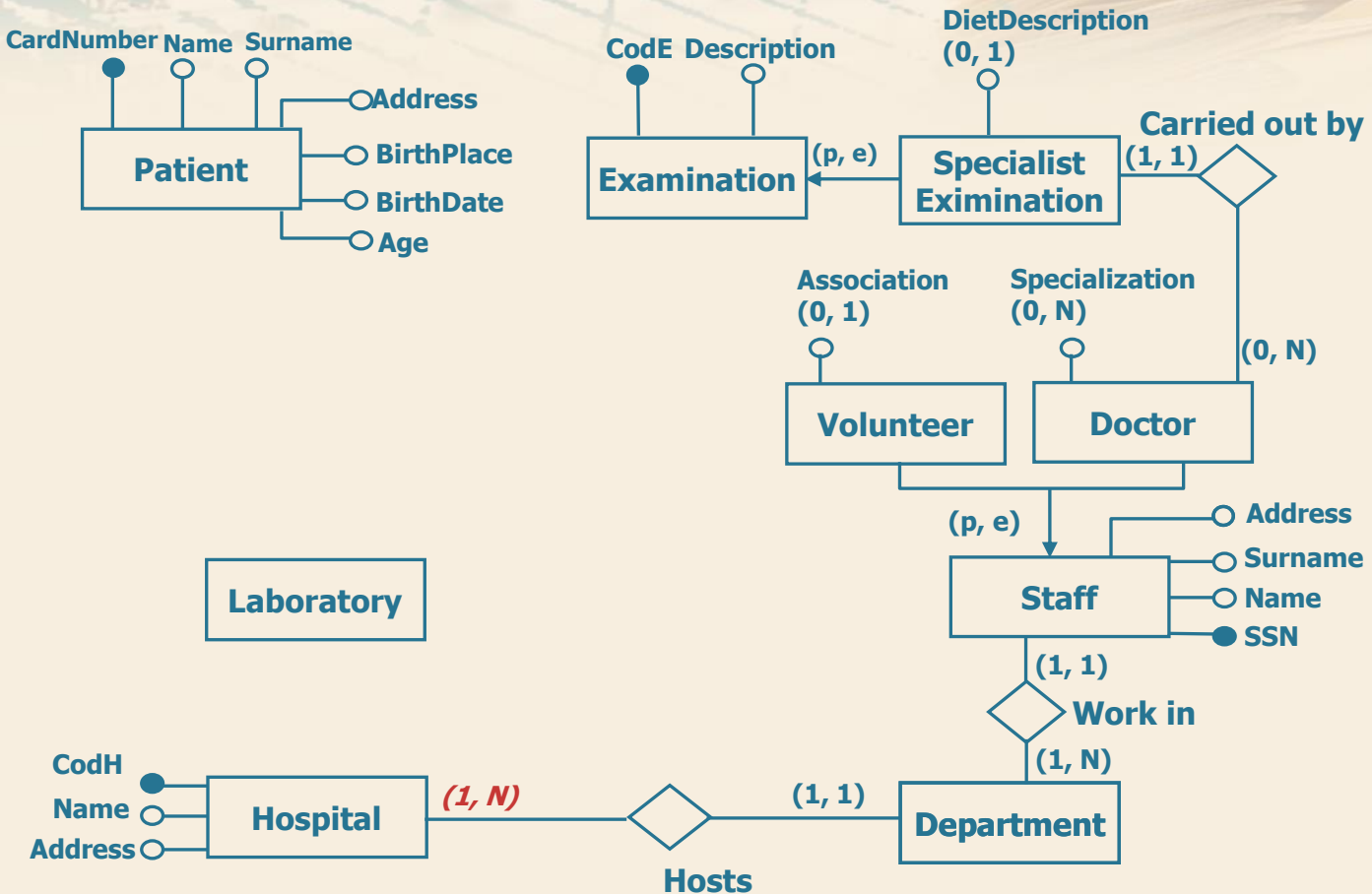
Relationship between Department and Hospital



Cardinality of the Hosts relationship



Cardinality of the Hosts relationship

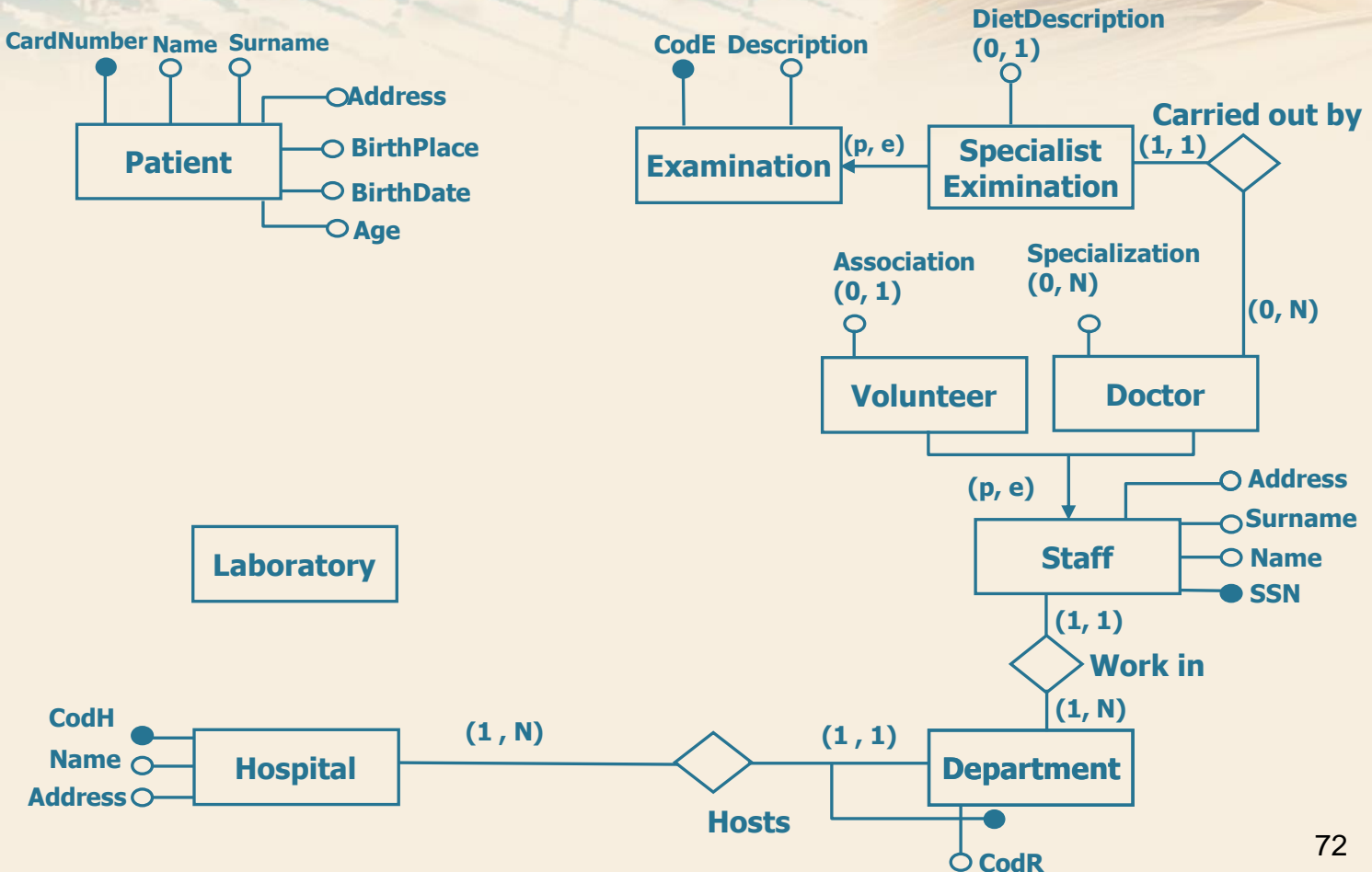




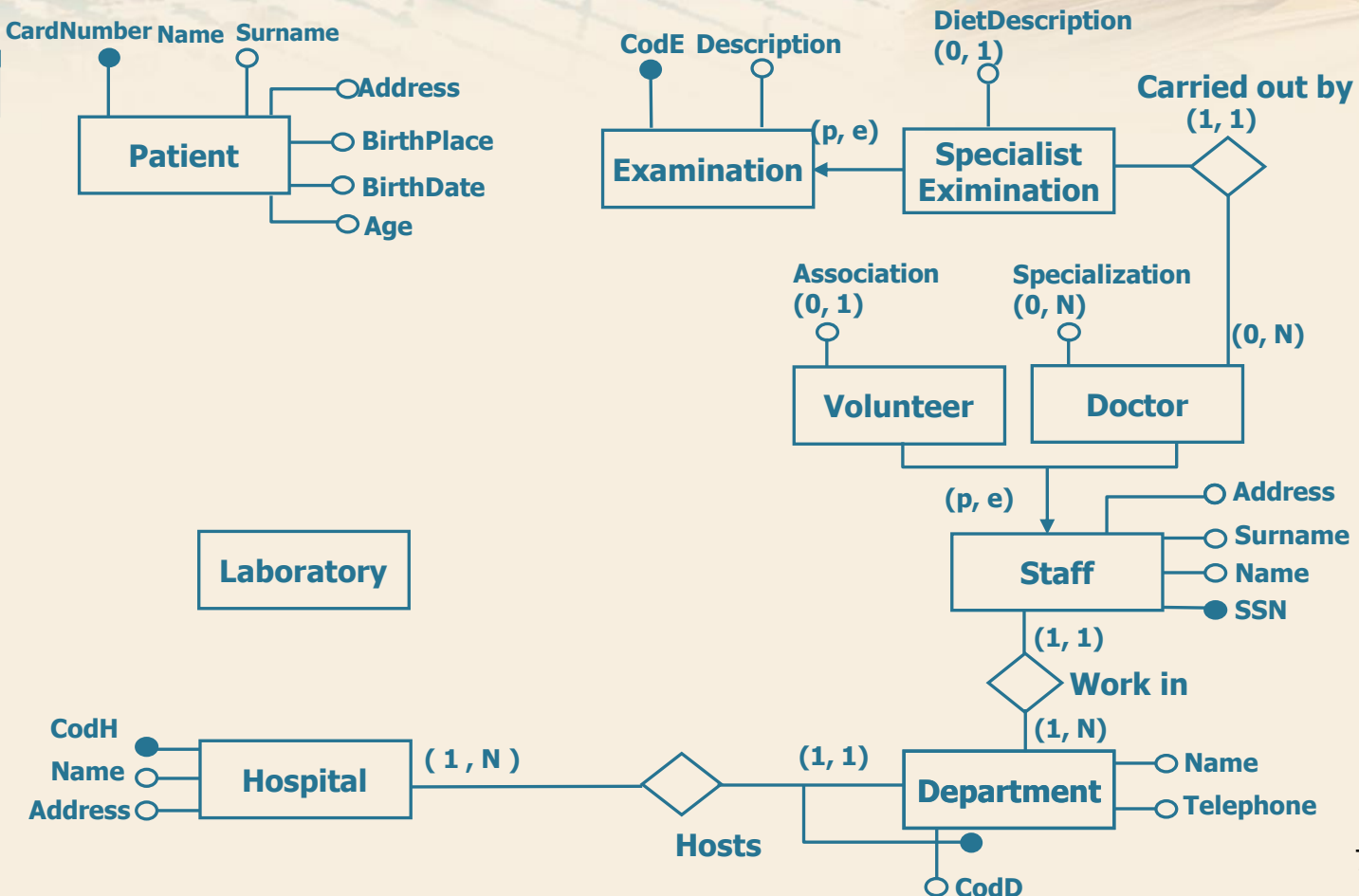
Department entity identifier

Each hospital is divided into departments identified by a unique numeric code and characterized by the department name and the telephone number.

Department entity identifier

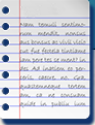


Refinement of the Department entity



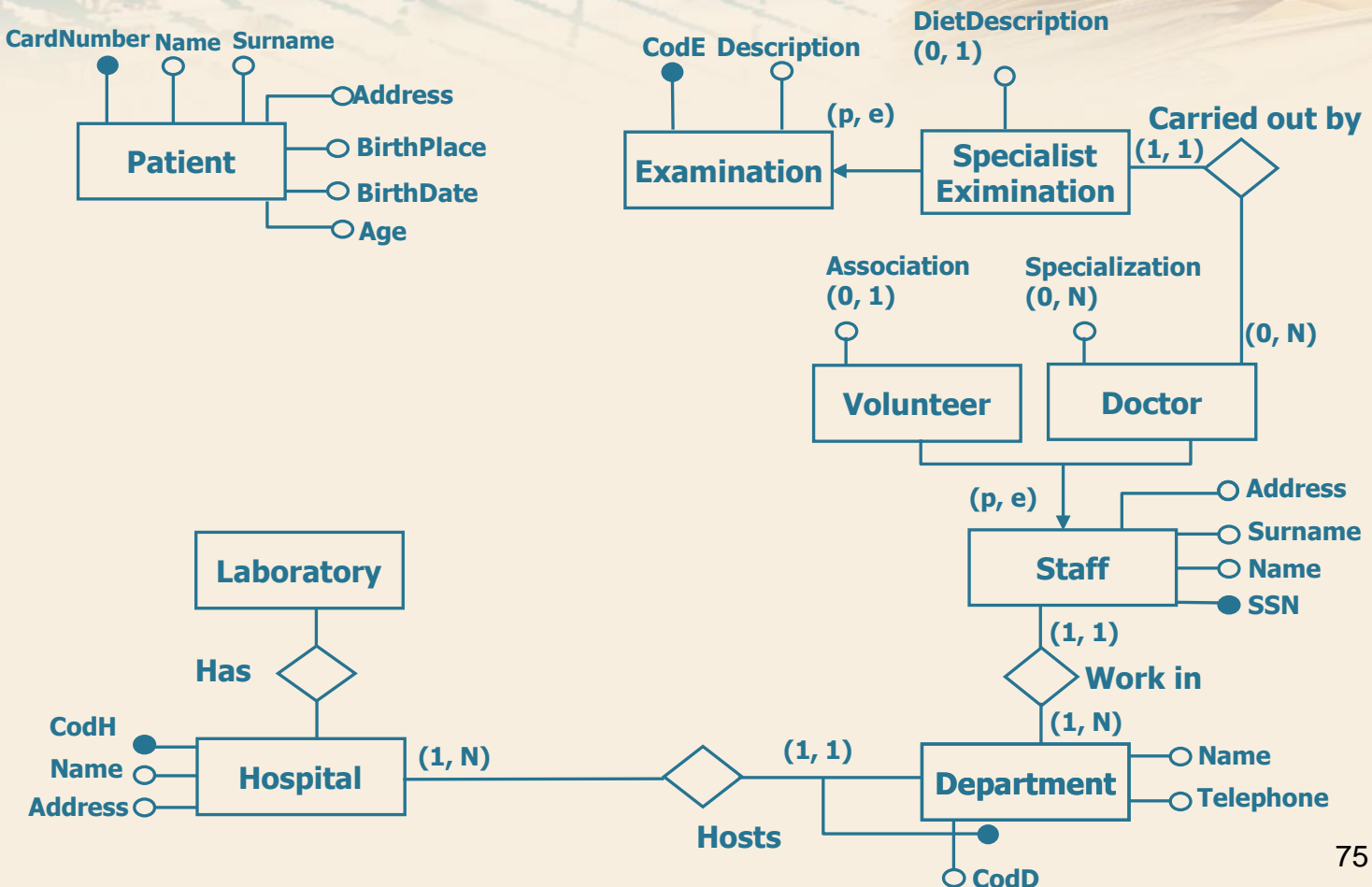


Relationship between Laboratory and Hospital

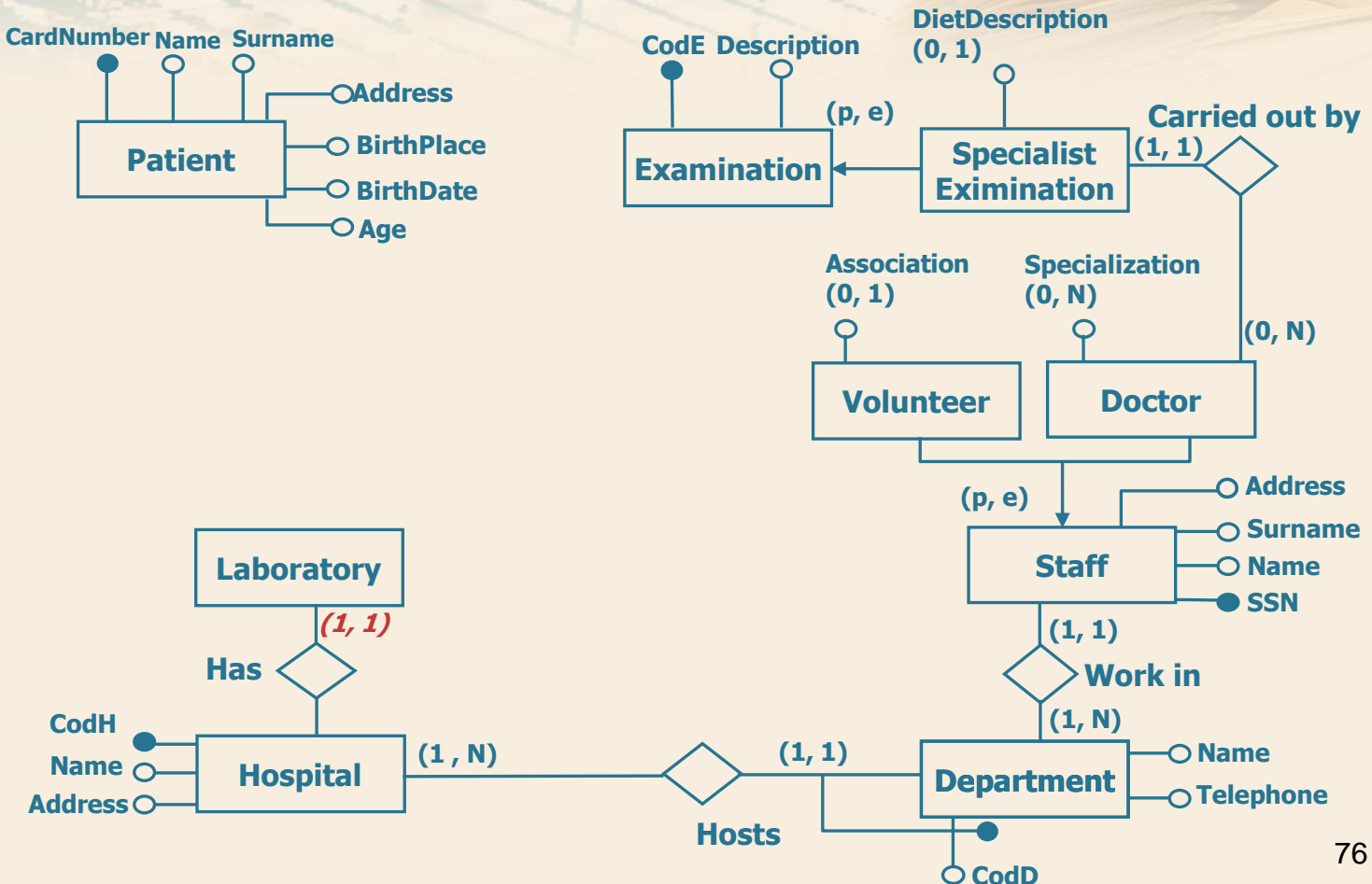


The laboratories that perform the tests are identified by a unique code within the hospital and are characterized by the name of the laboratory, the location plan and the room number.

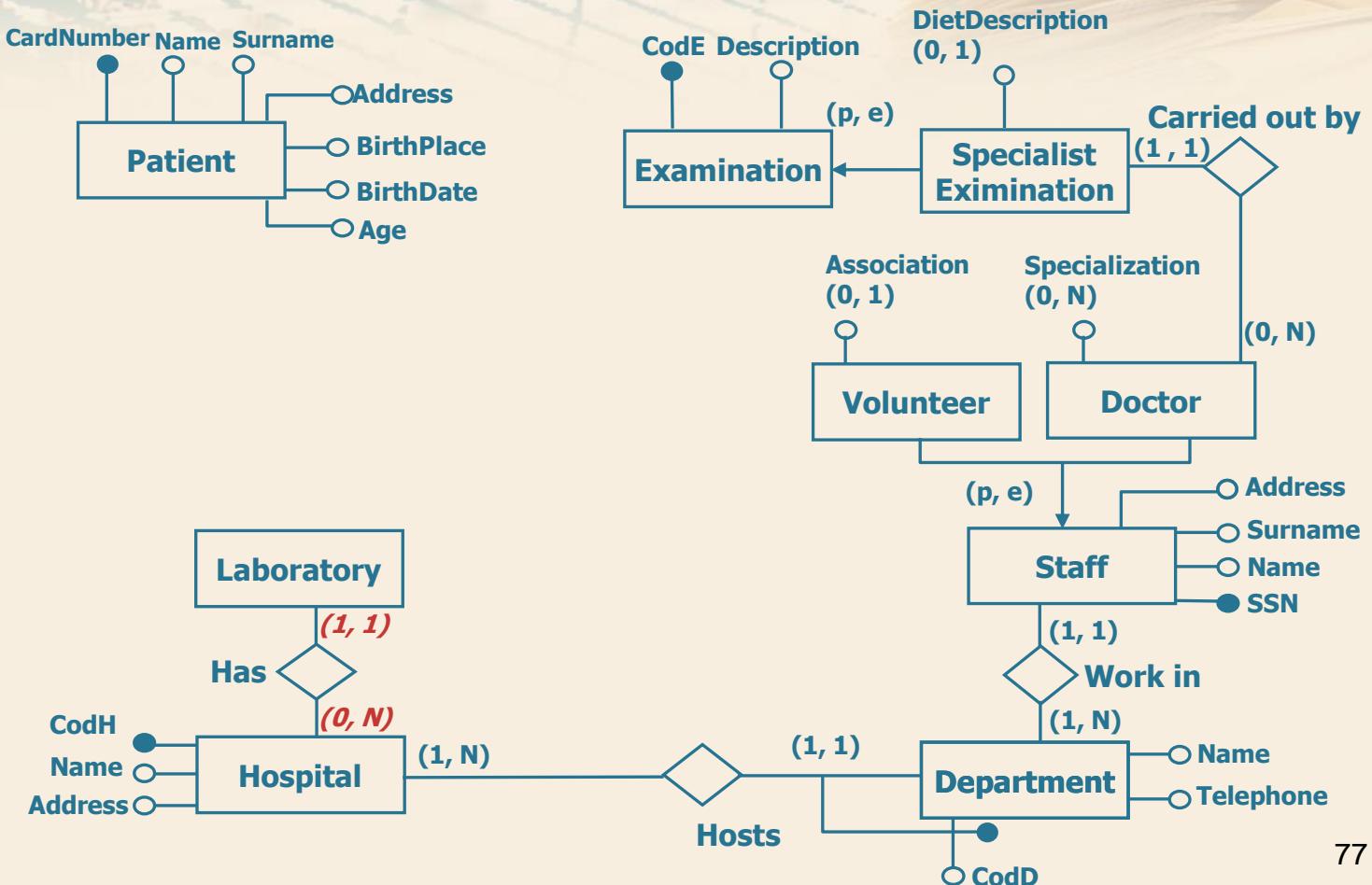
Relationship between Laboratory and Hospital



Cardinality of the Has relationship



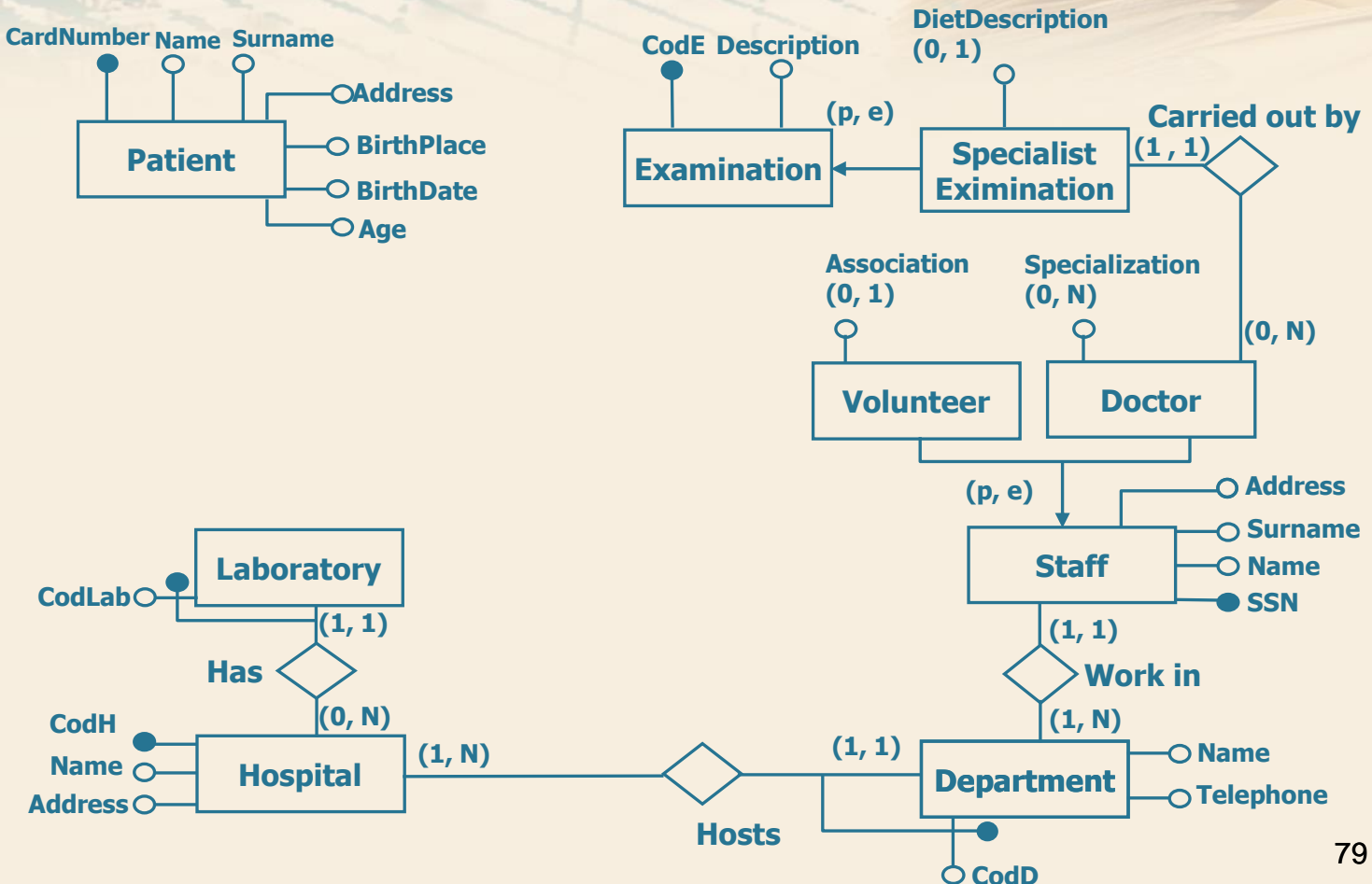
Cardinality of the Has relationship



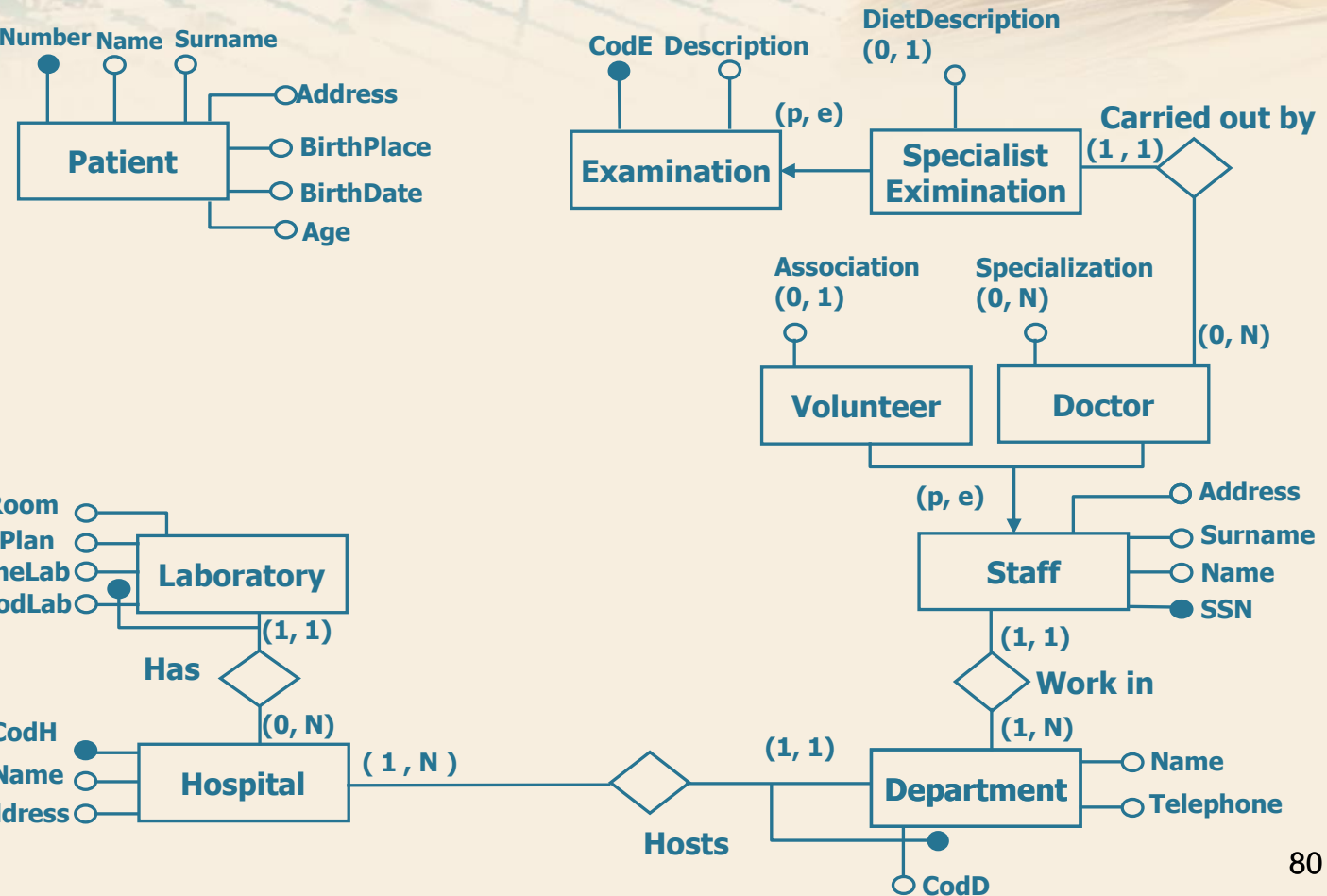
Relationship between Laboratory and Hospital

The laboratories that perform the tests are identified by a unique code within the hospital and they are characterized by the name of the laboratory, the location plan and the room number.

Laboratory entity identifier



Refinement of the Laboratory entity





Conceptual design – time I

Design example: representation of time



Representation of time

- It is necessary to explicitly represent the passage of time in the case of
- representation of events
 - changes in the information content of entities or time attributes

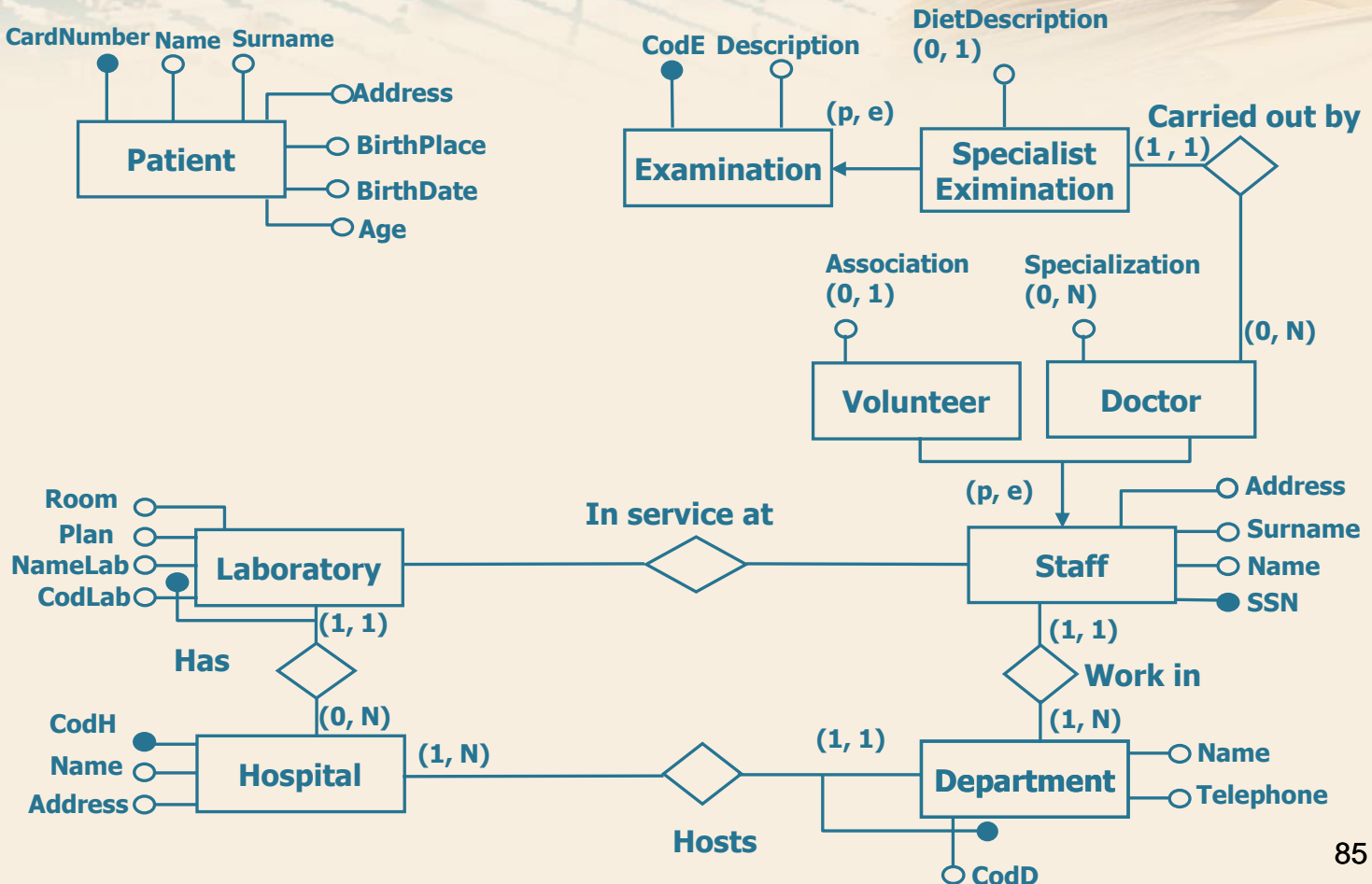
Representation of time

- It is necessary to explicitly represent the passage of time in the case of
 - representation of events
 - changes in the information content of entities or time attributes
- Various modes of representation are possible
 - by means of N-ary relationships with a time entity
 - through historicized entities
 - through binary relationships with a time entity

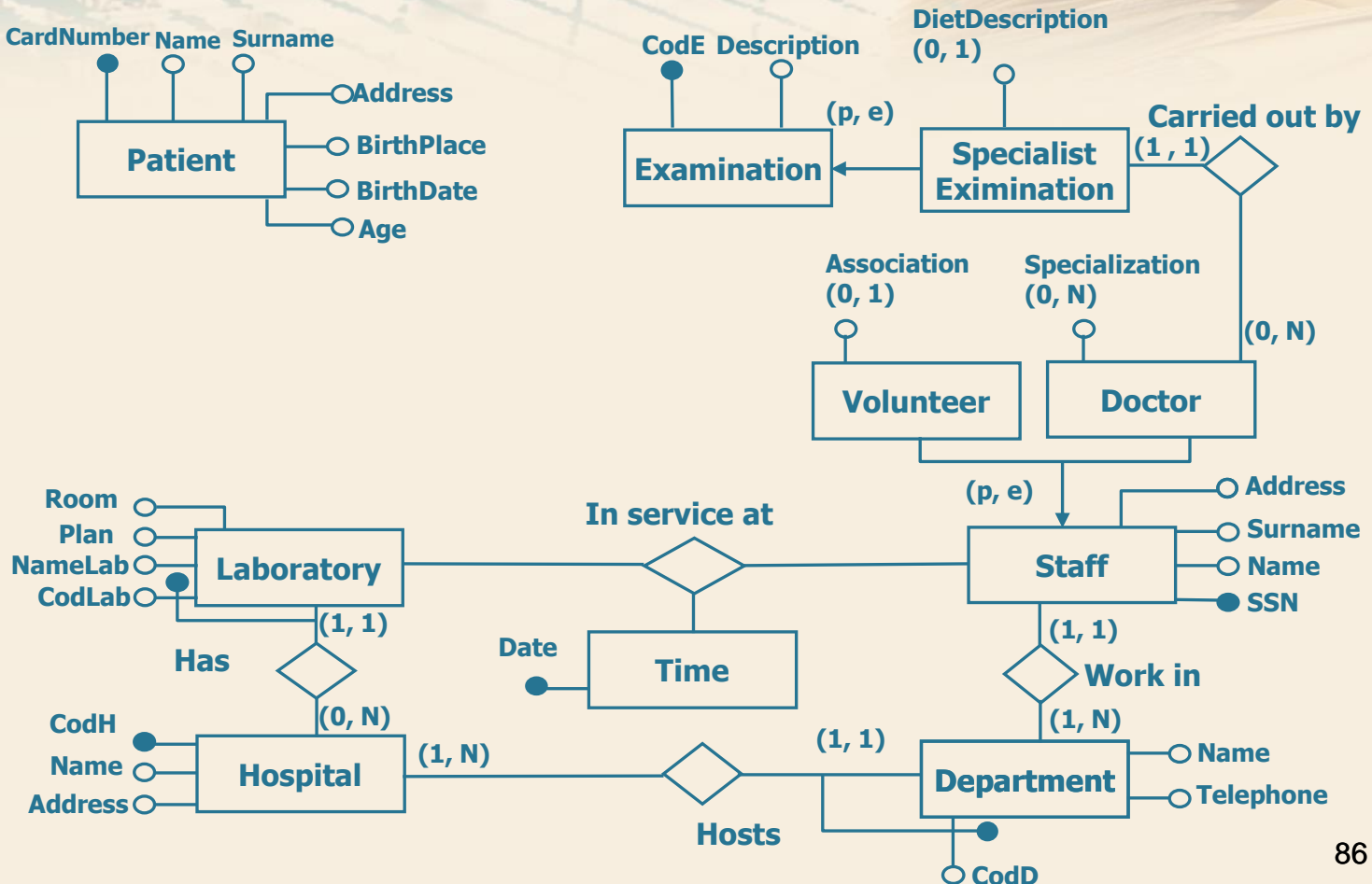
Relationship between Staff and Laboratory

For each member of the laboratory staff, the days and laboratories in which he works are stored. It should be borne in mind that during the same day each member of the staff can work in several laboratories.

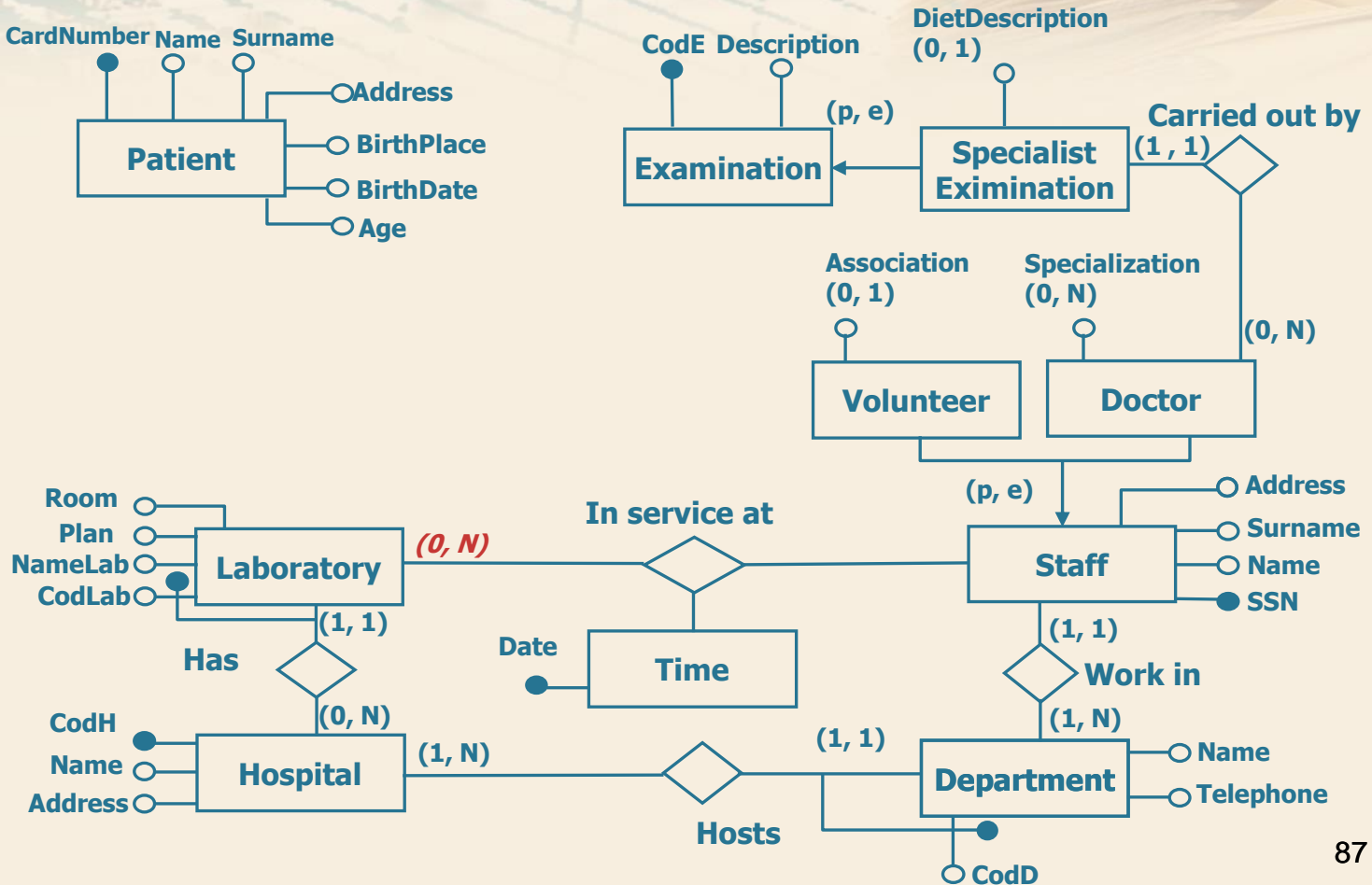
Relationship between Staff and Laboratory



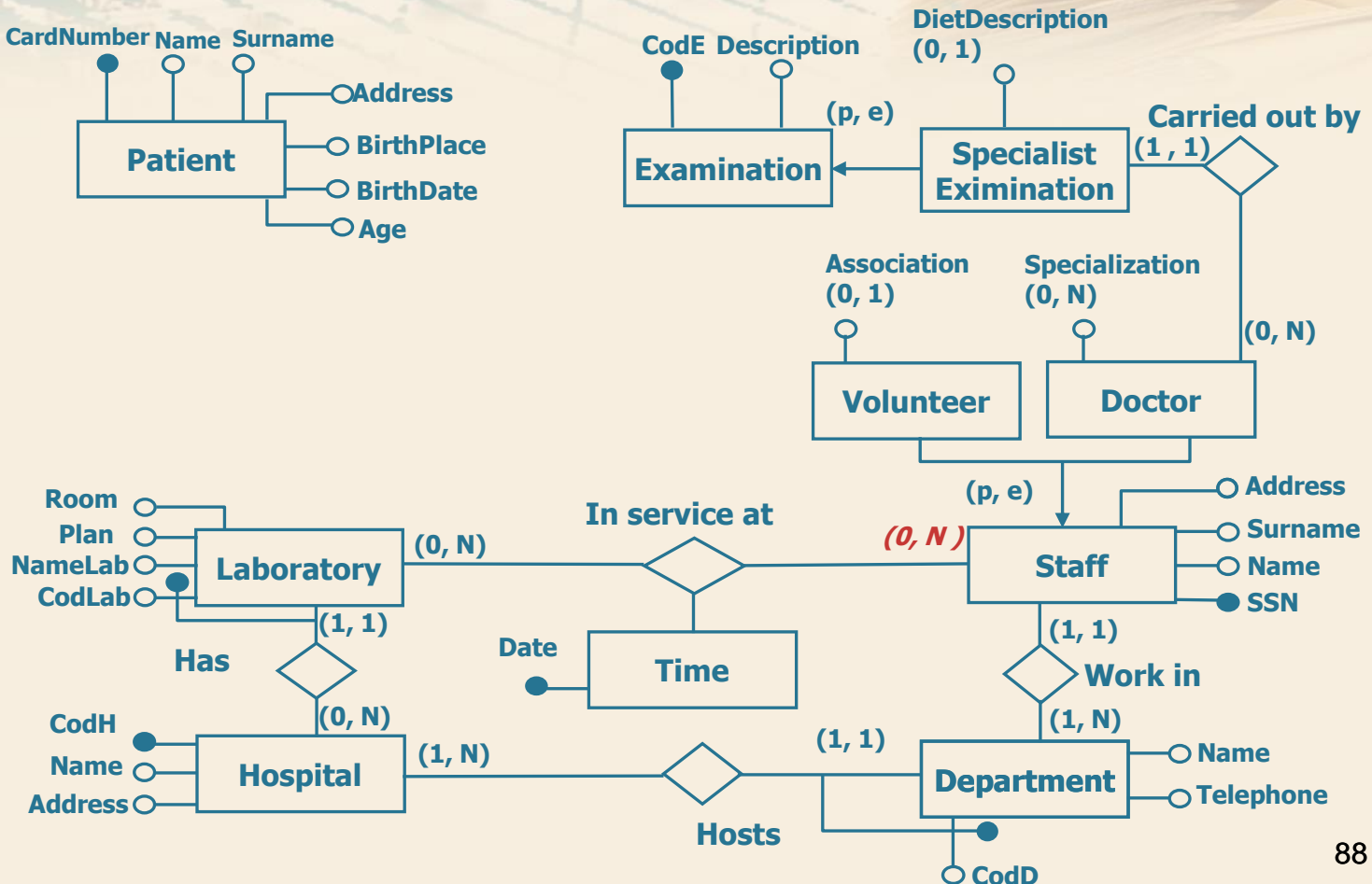
Historicalization of the In service at relationship



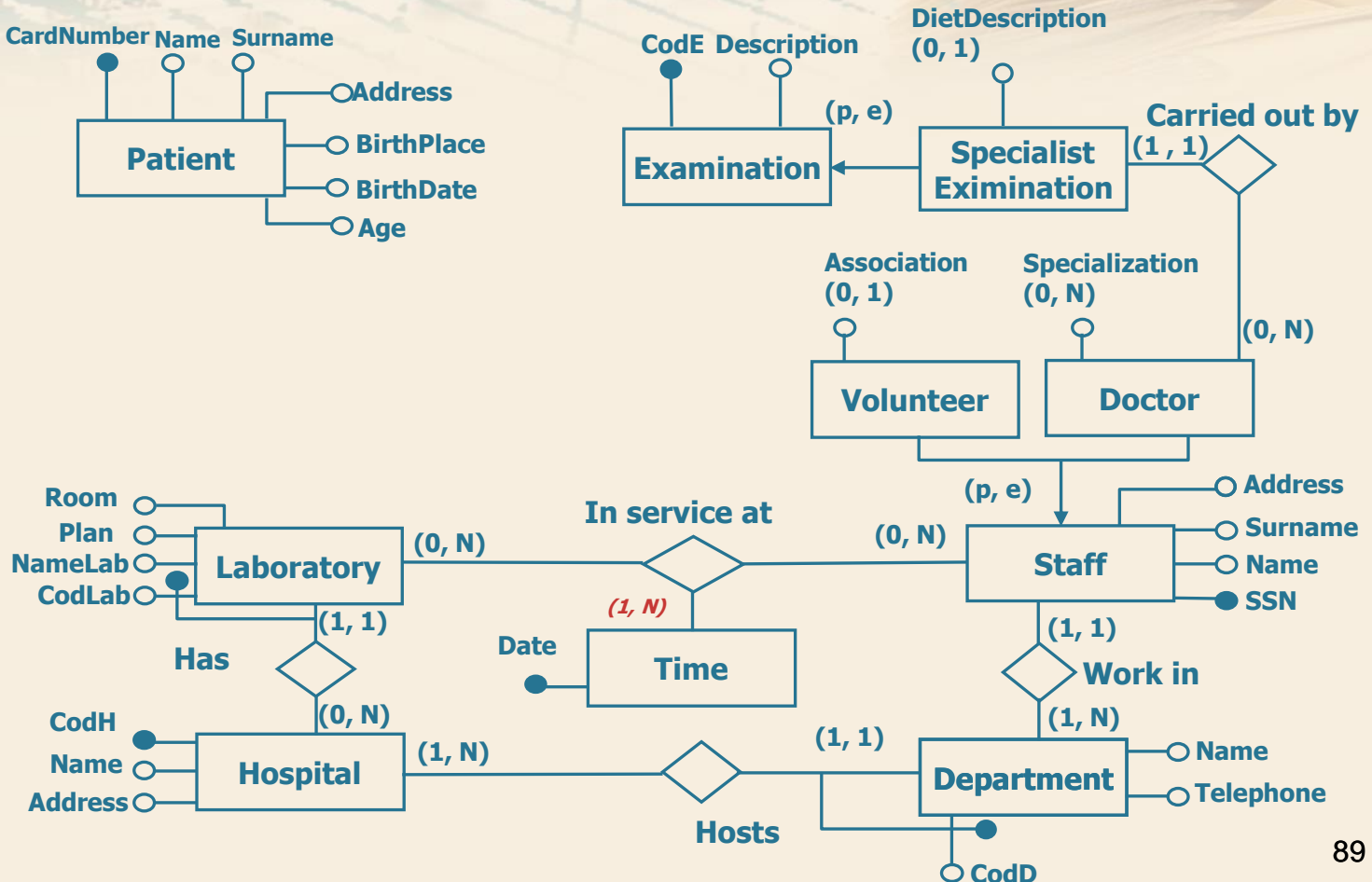
Cardinality of the In service at relationship



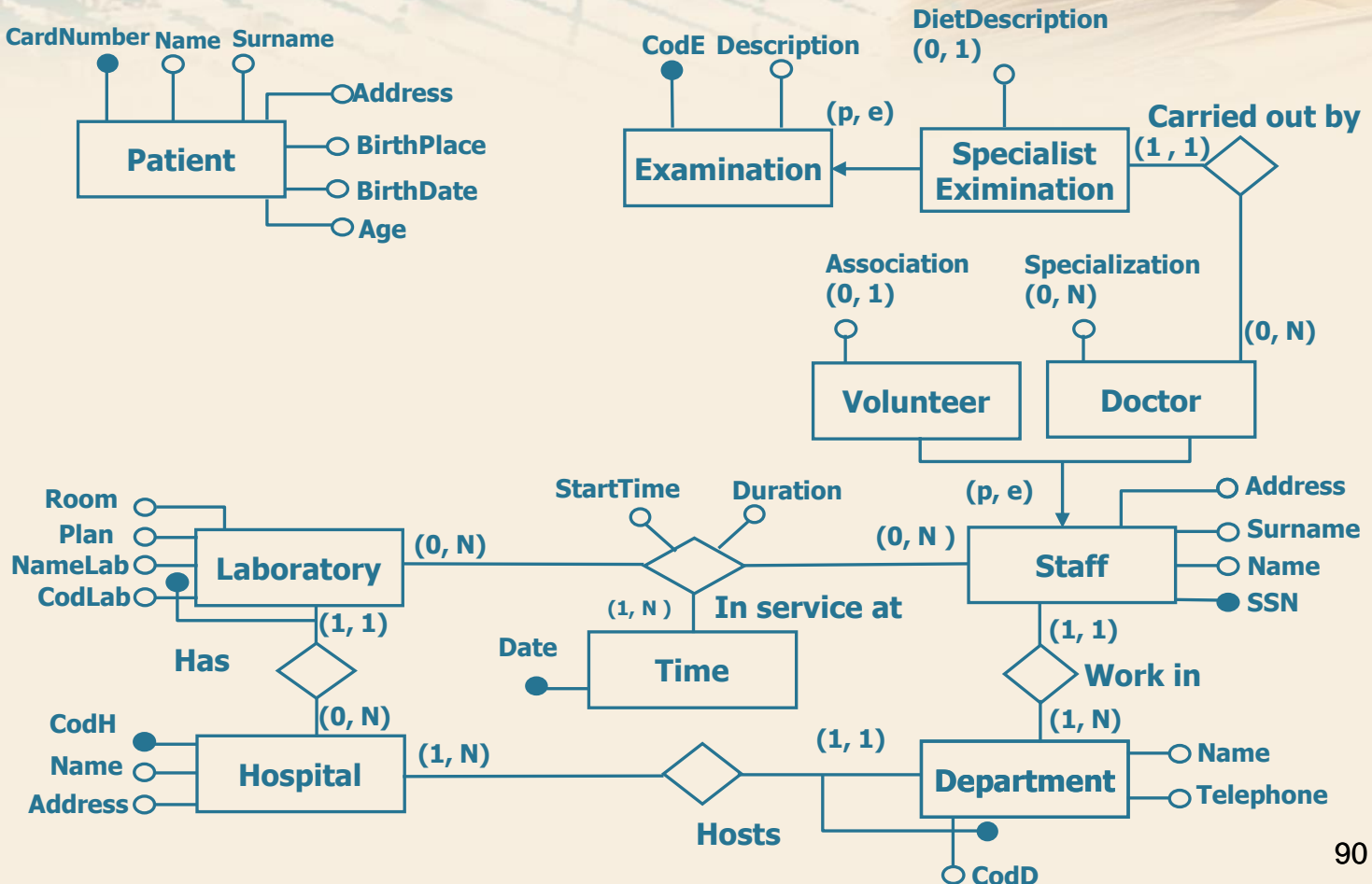
Cardinality of the In service at relationship



Cardinality of the In service at relationship



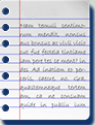
Refinement of the In service at relationship





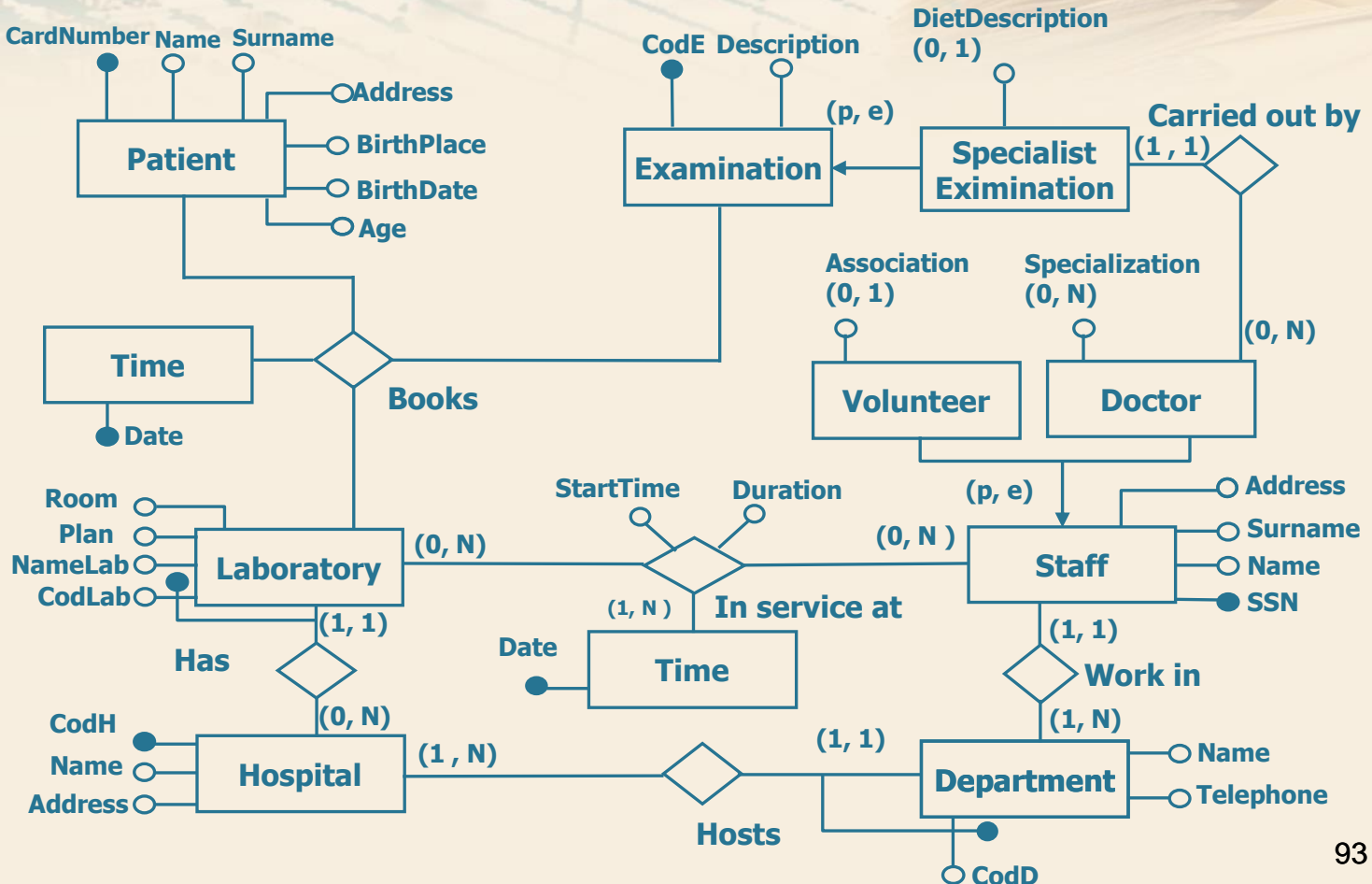
Conceptual design – time II

Representation of the reservation

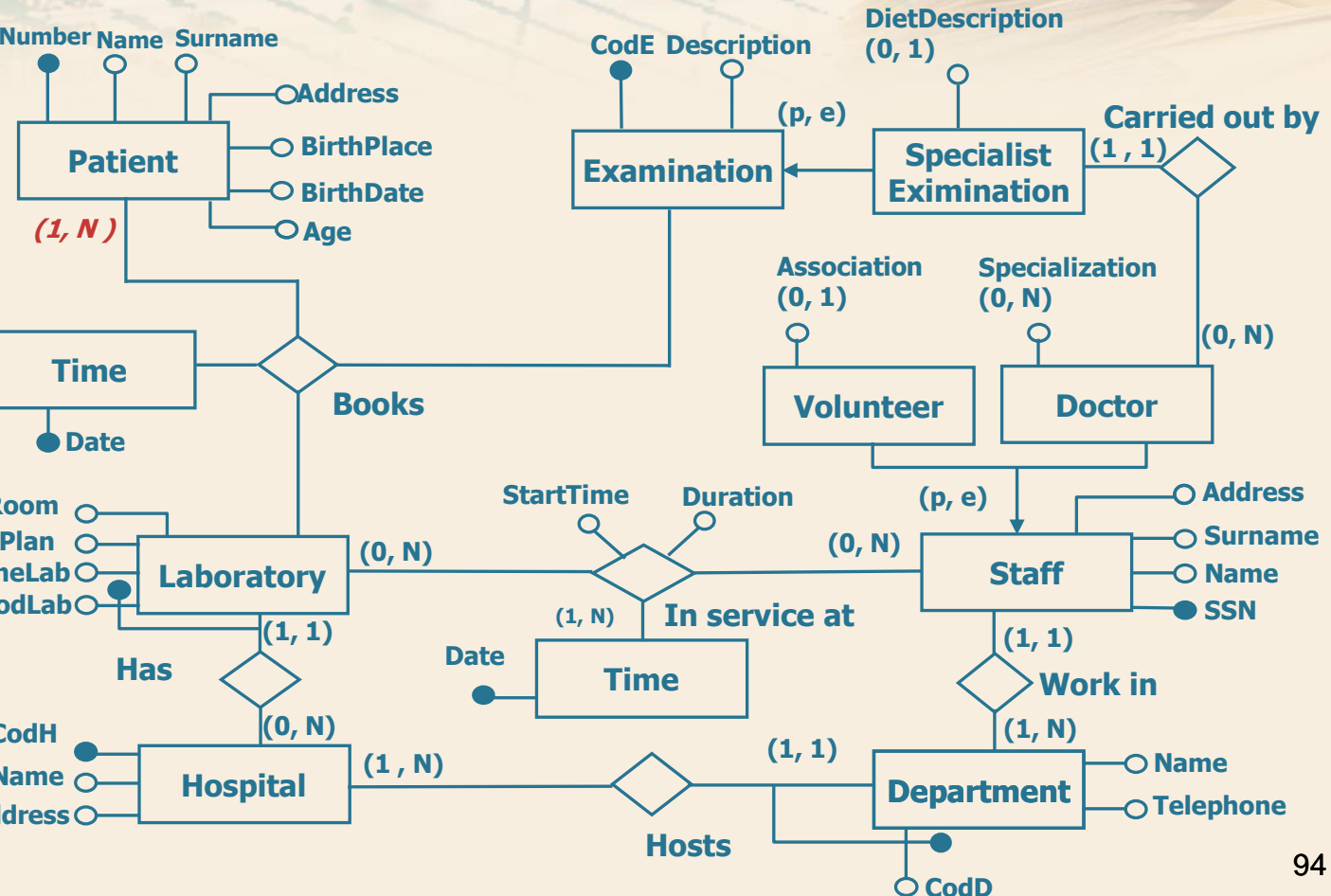


Each exam requires a reservation. For each exam reservation made by a patient, the date and time of the exam, the laboratory where it is performed, the cost of the ticket and the information about the exam being urgent or not are stored. Please note that each patient can make multiple reservations for the same exam on different dates and the same exam cannot be repeated on the same day by the same patient, even in different laboratories.

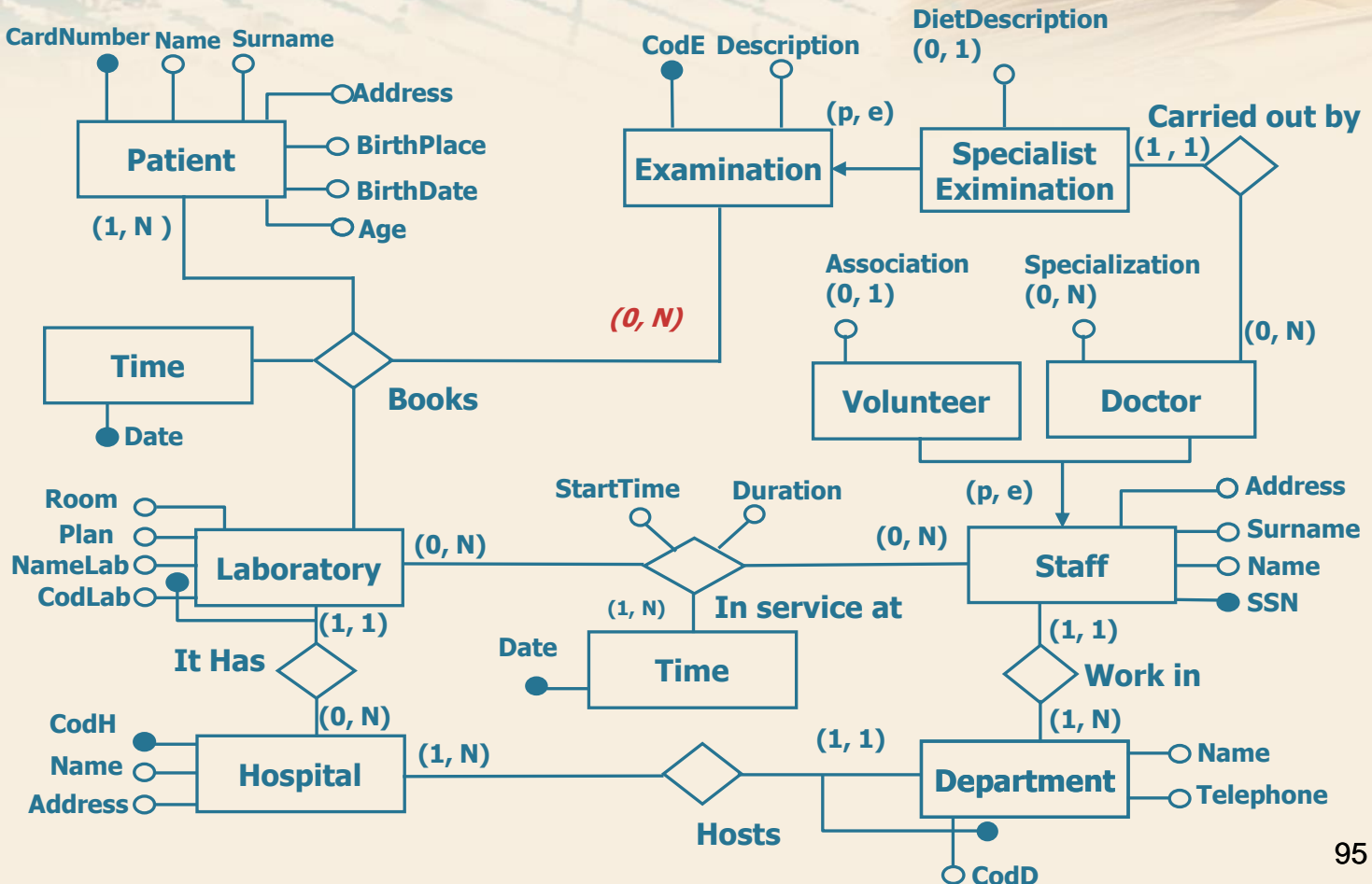
Representation of the reservation



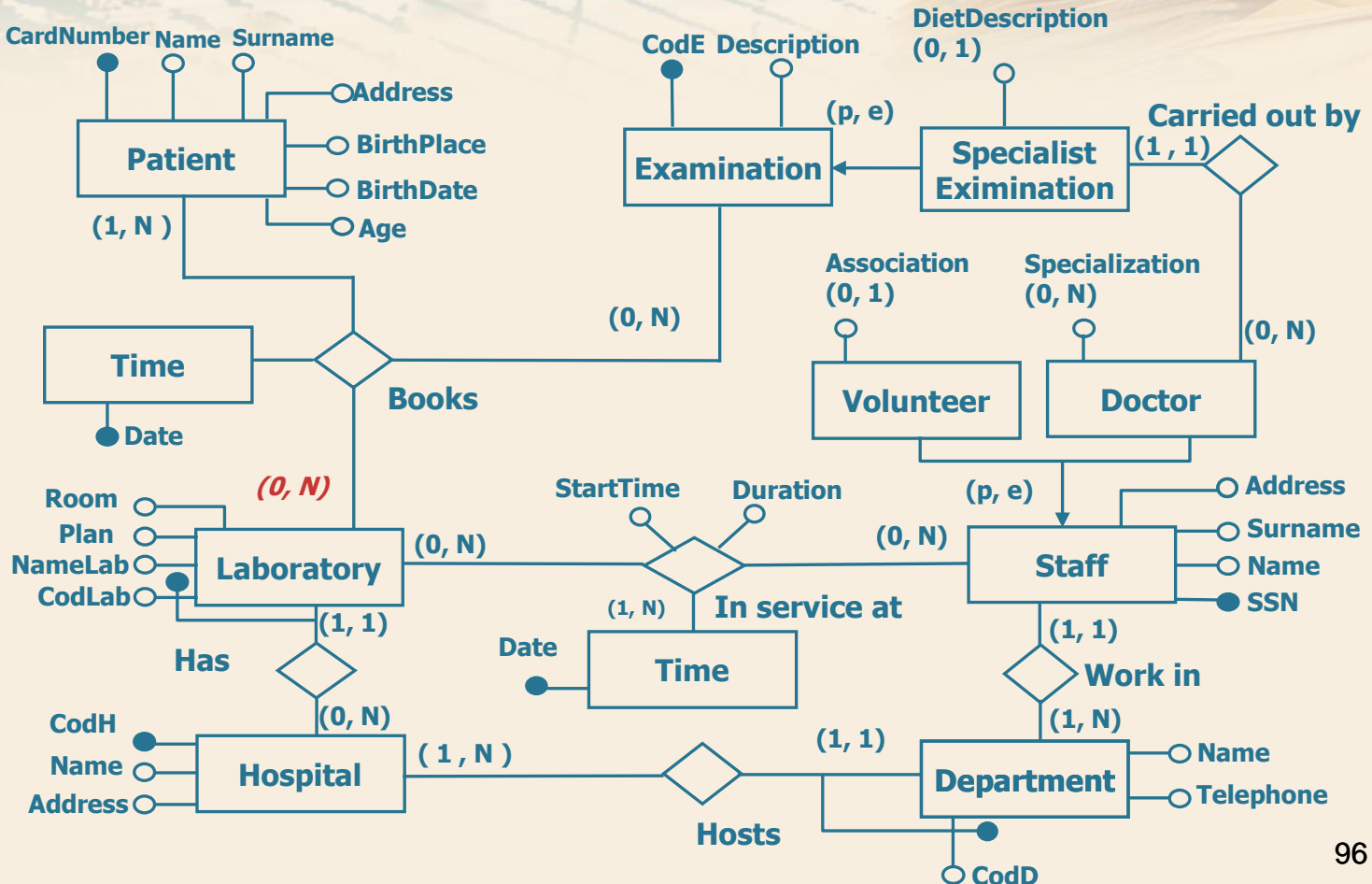
Cardinality of the Books relationship



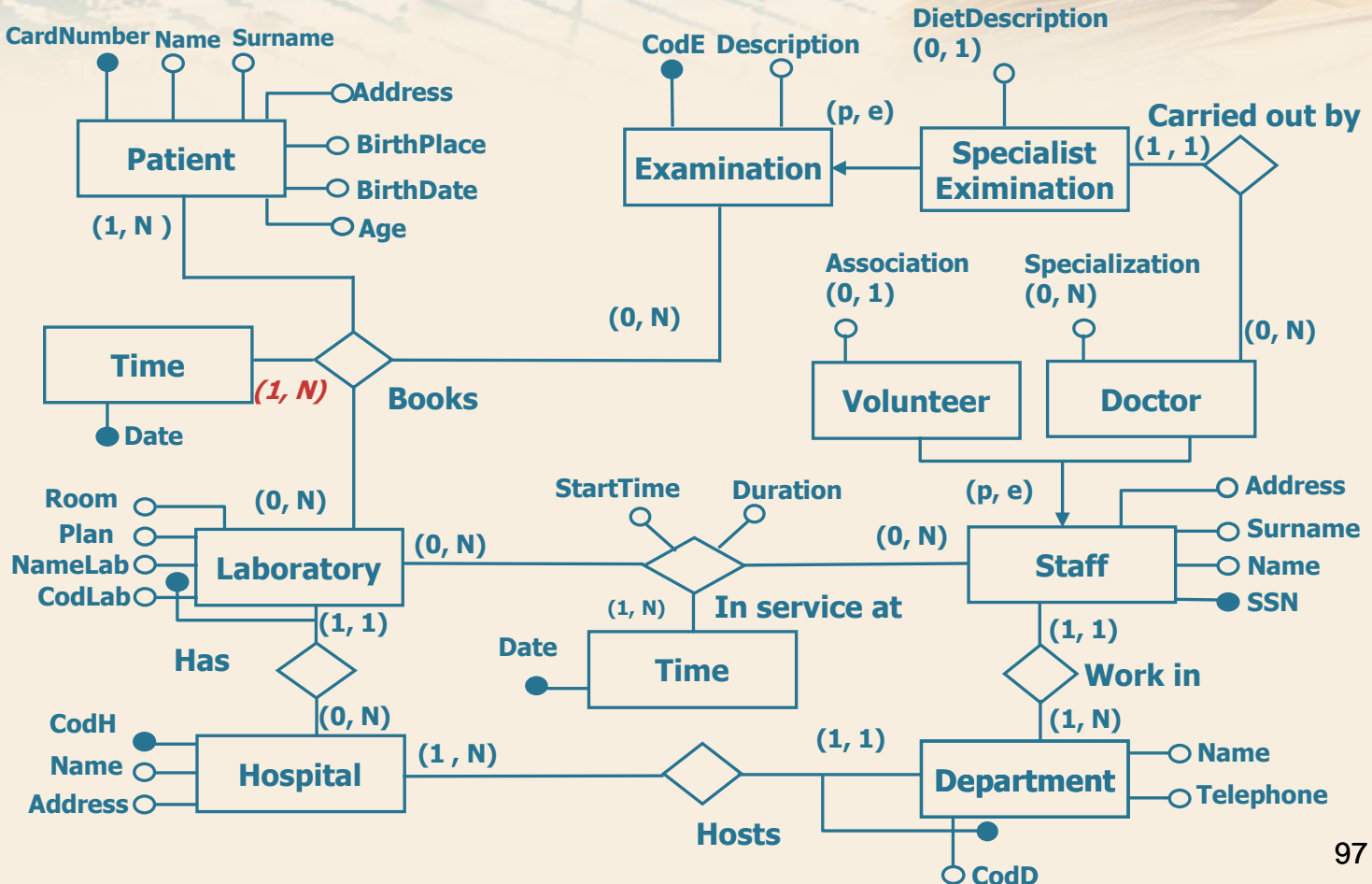
Cardinality of the Books relationship



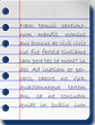
Cardinality of the Books relationship



Cardinality of the Books relationship

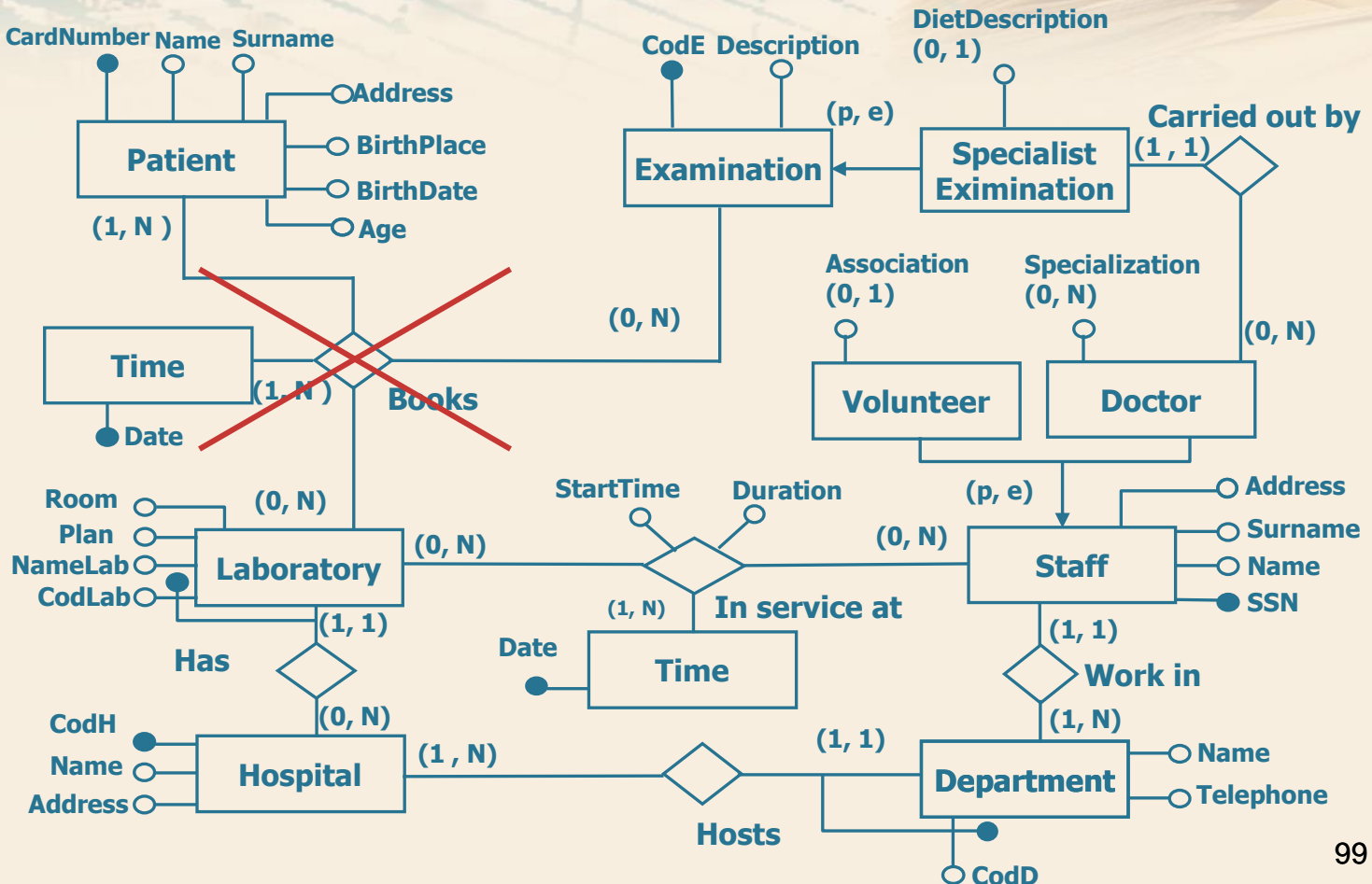


Reservation constraints

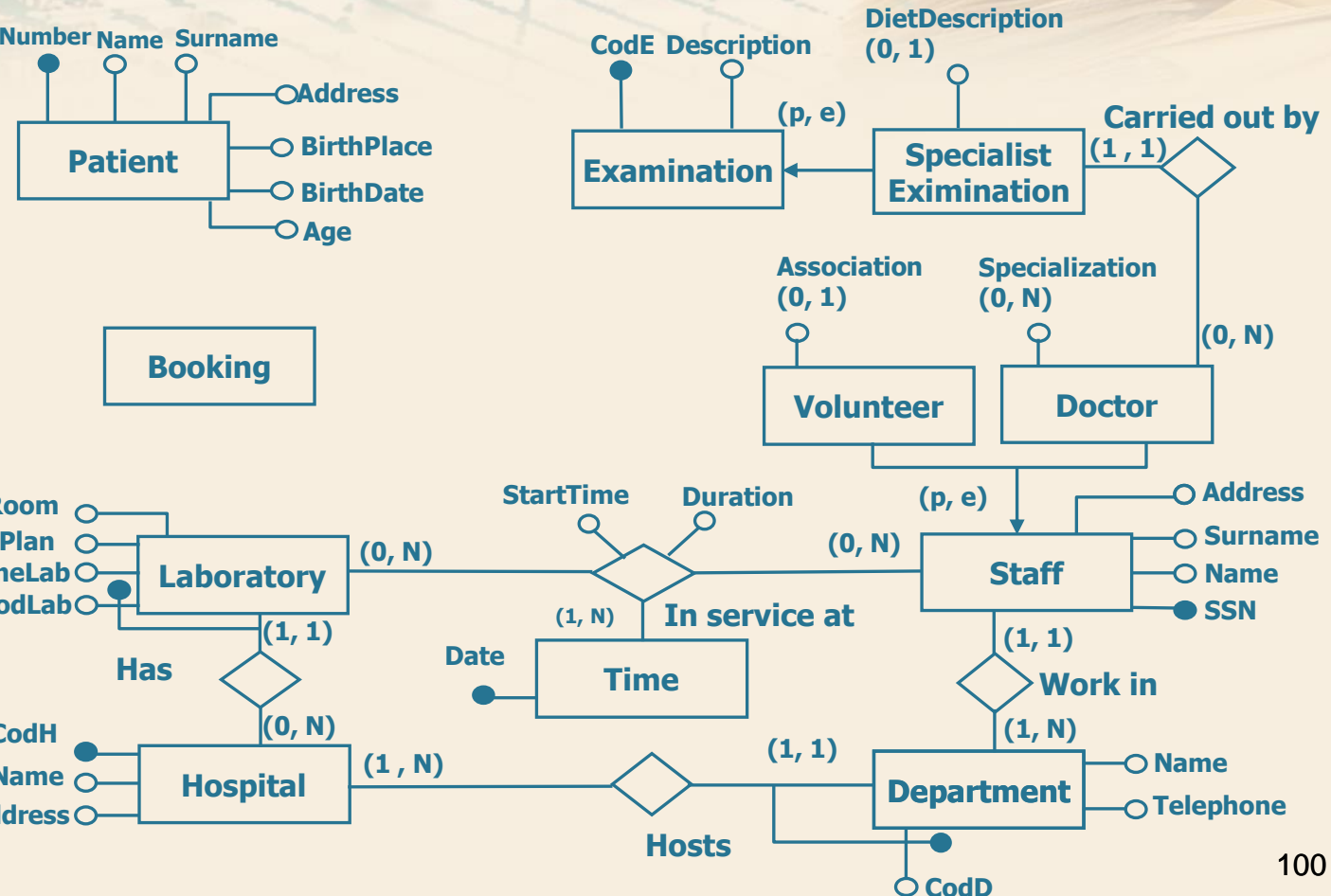


Each exam requires a reservation.
For each exam reservation made by a patient, the date and time of the exam, the laboratory where it is performed, the cost of the ticket and the information about the exam being urgent or not are stored. *Please note that each patient can make multiple reservations for the same exam on different dates and the same exam cannot be repeated on the same day by the same patient, even in different laboratories.*

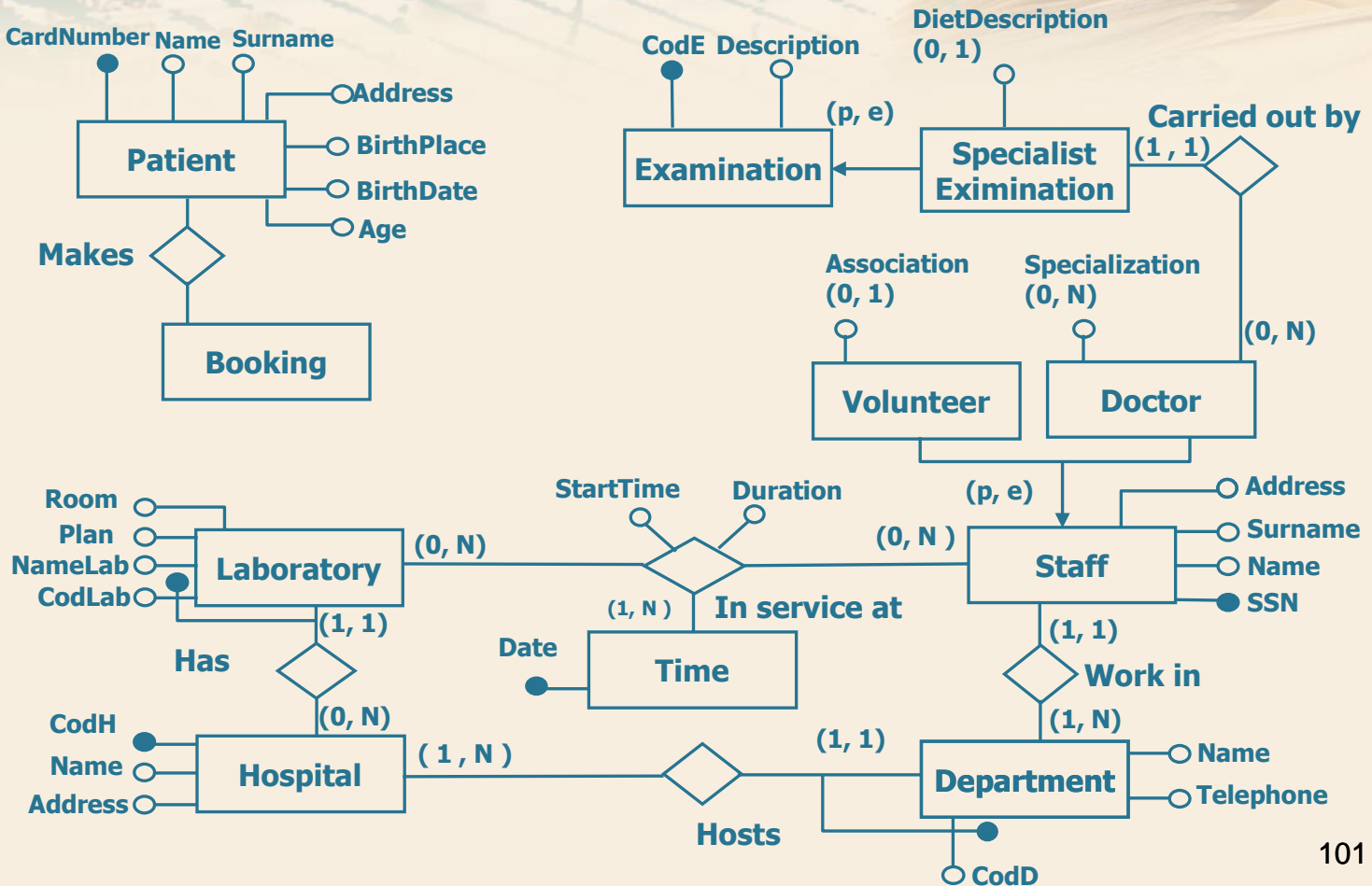
Representation of the booking



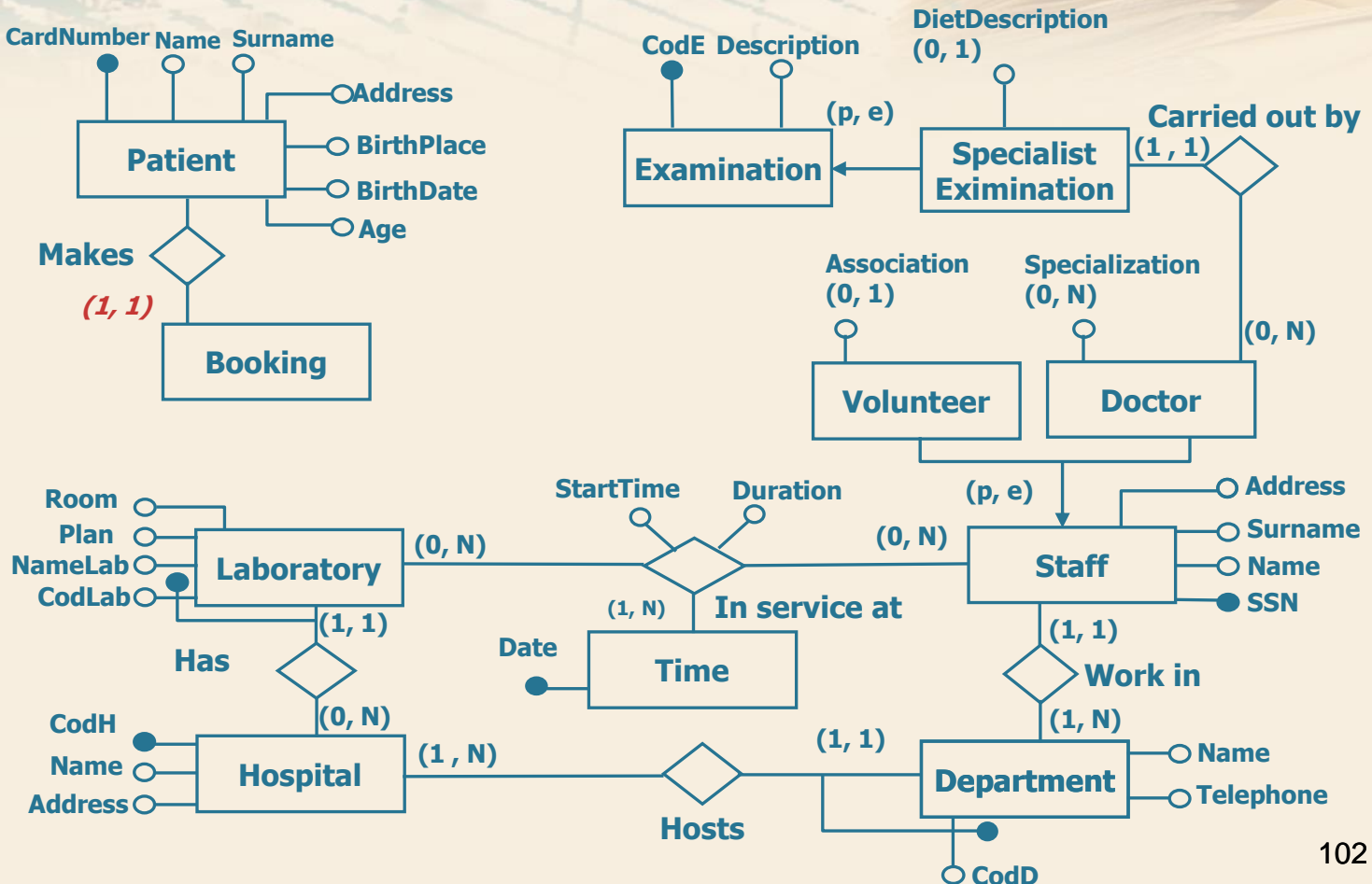
Introduction of the Booking entity



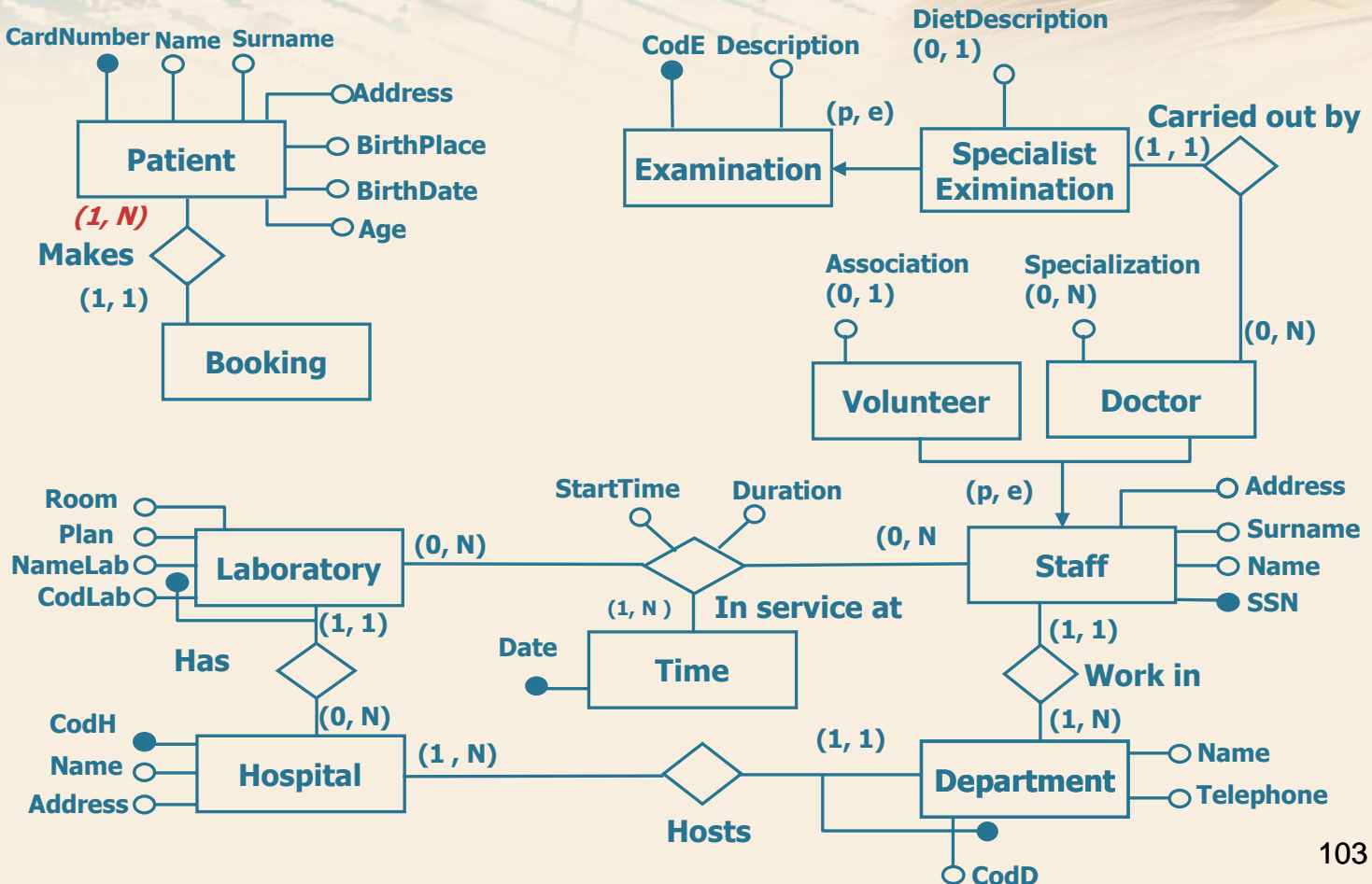
Relationship between Booking and Patient



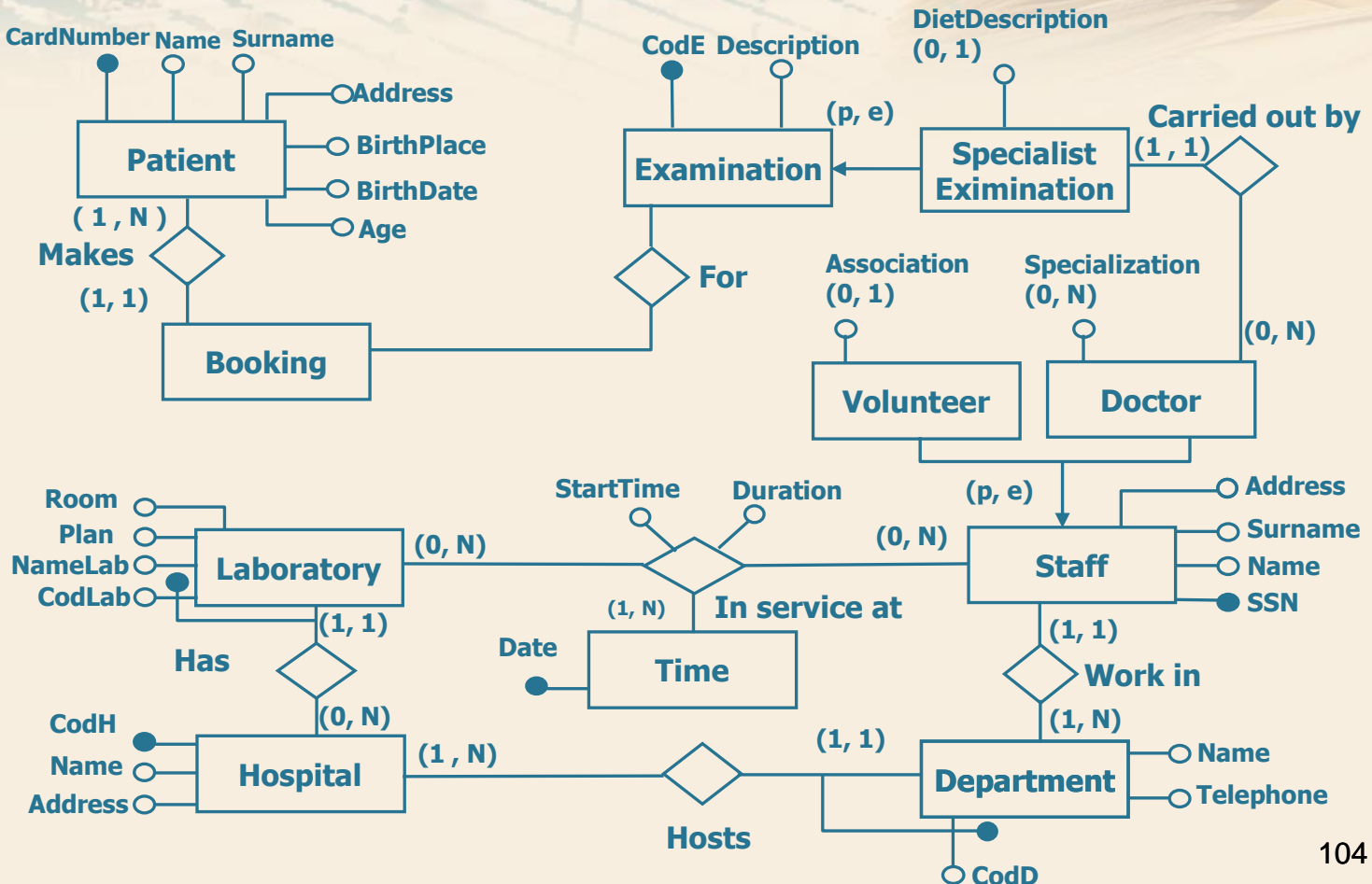
Cardinality of the Makes relationship



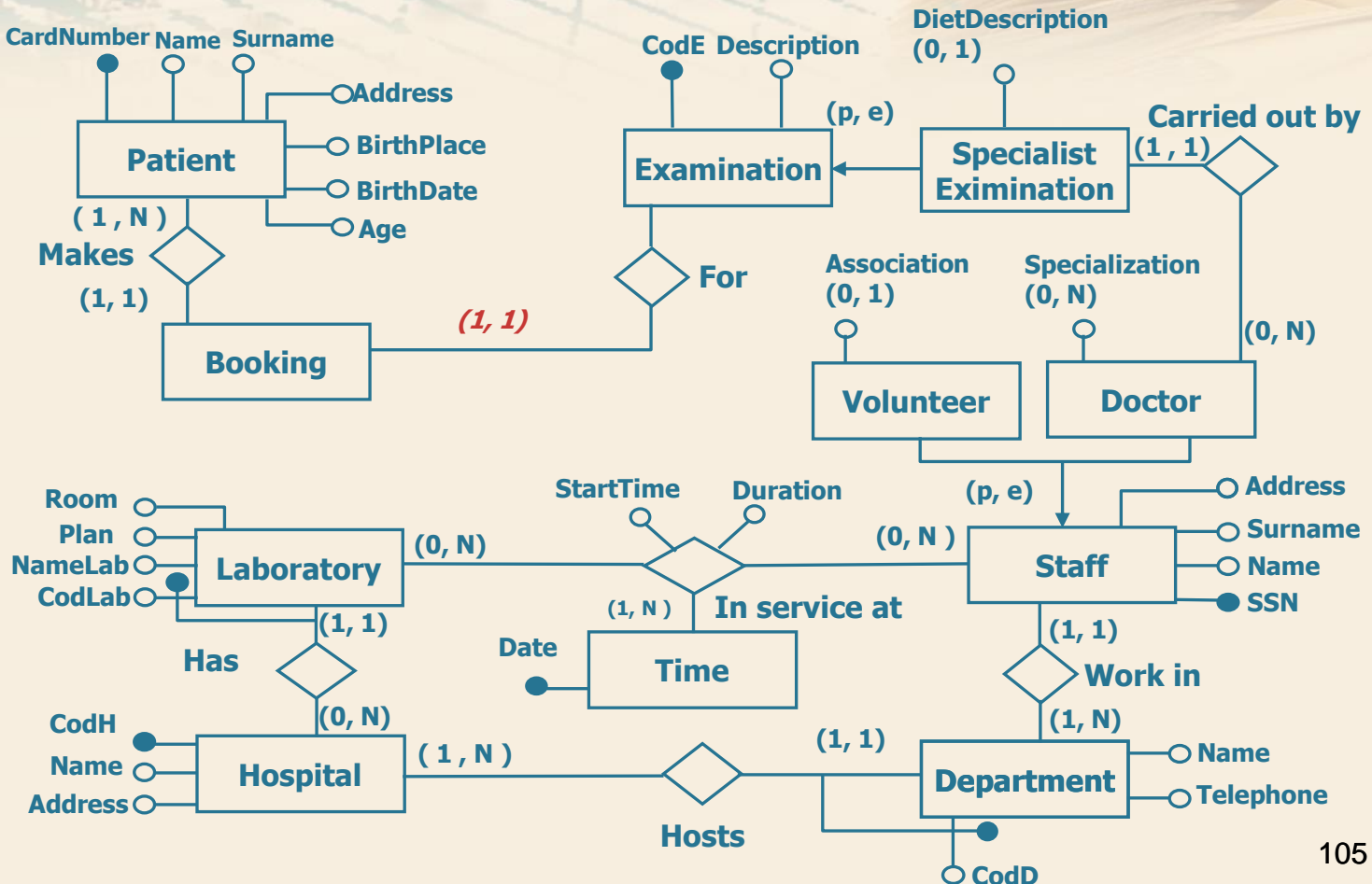
Cardinality of the Makes relationship



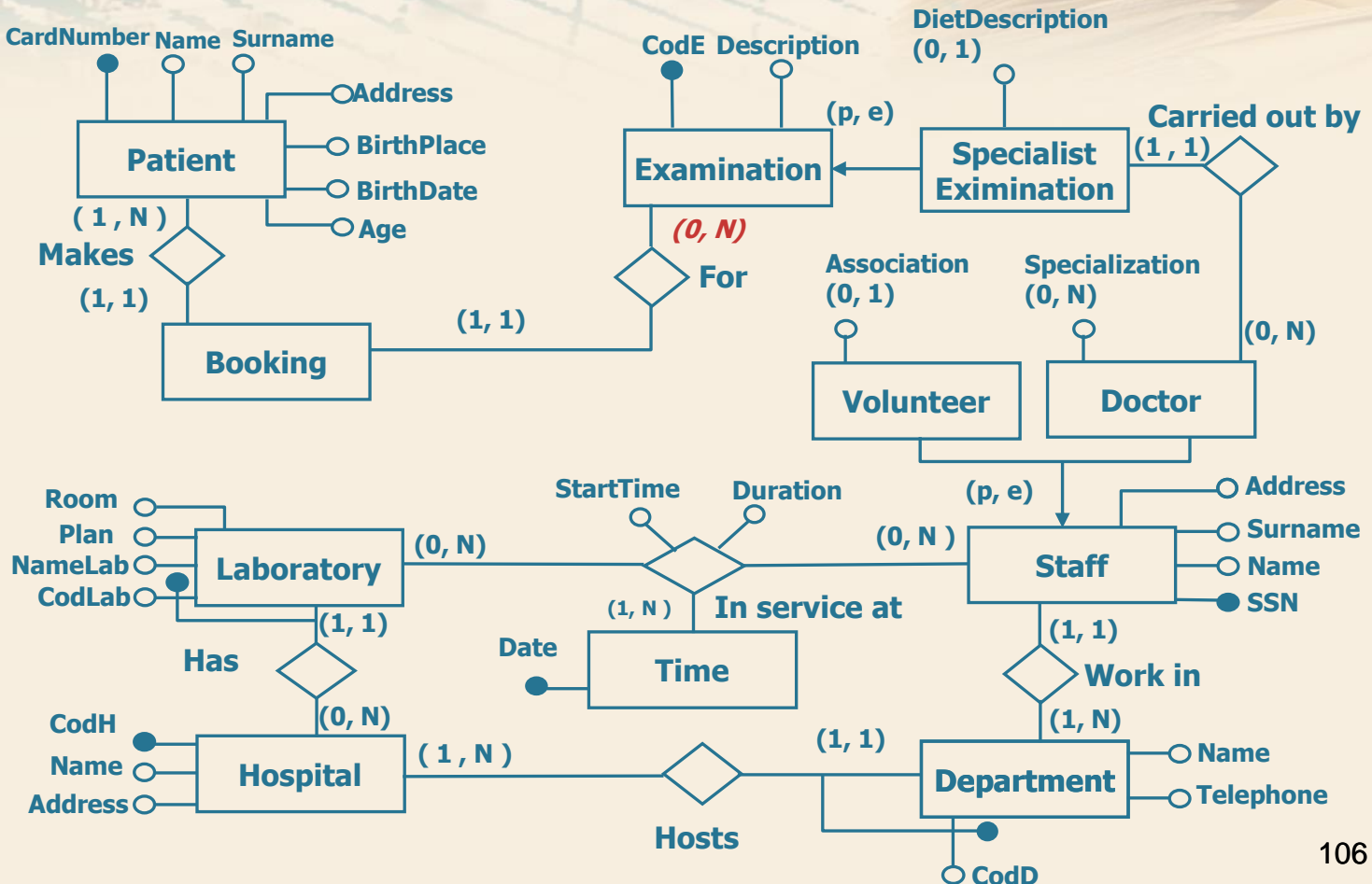
Relationship between Booking and Examination



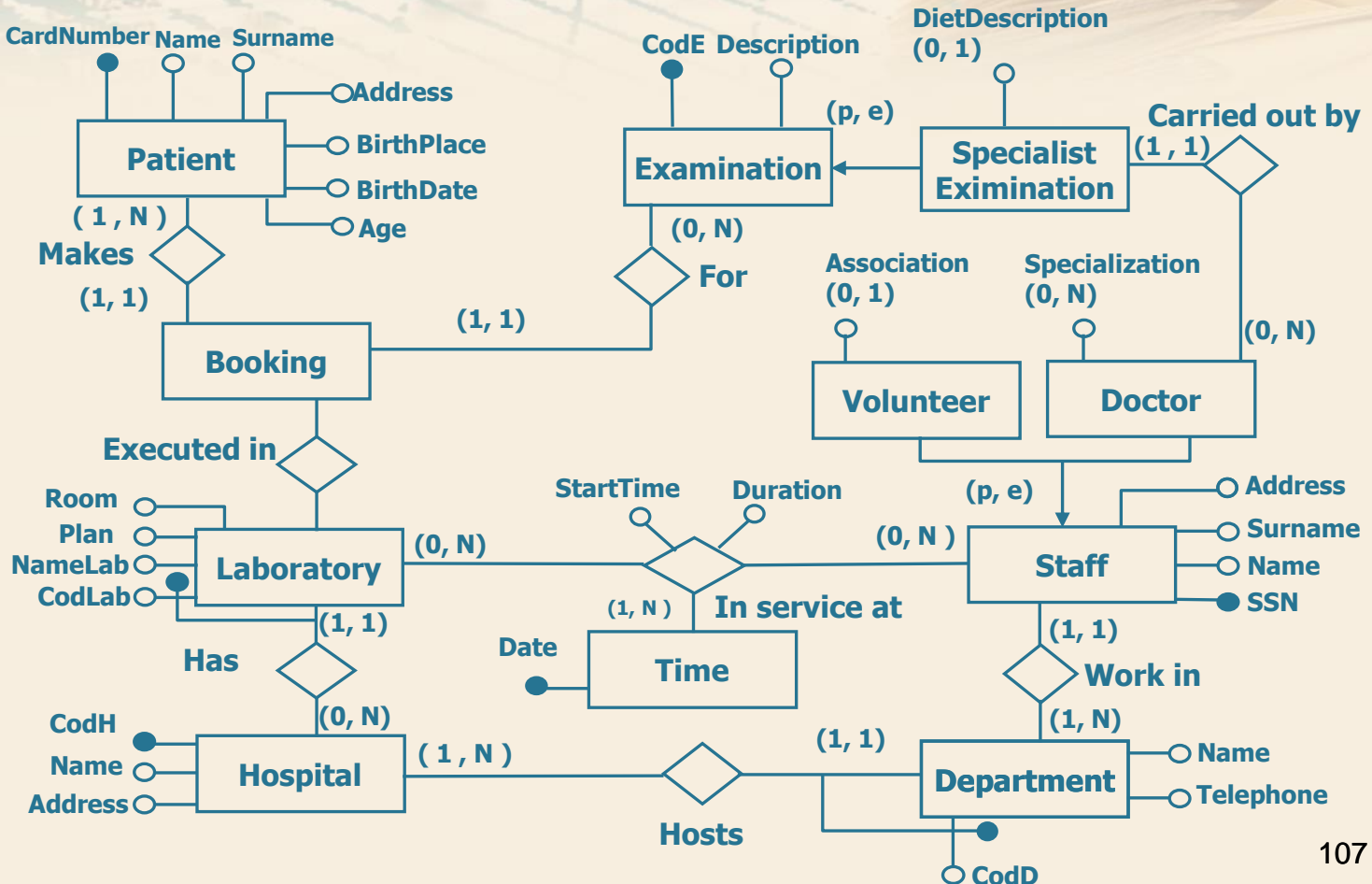
Cardinality of the For relationship



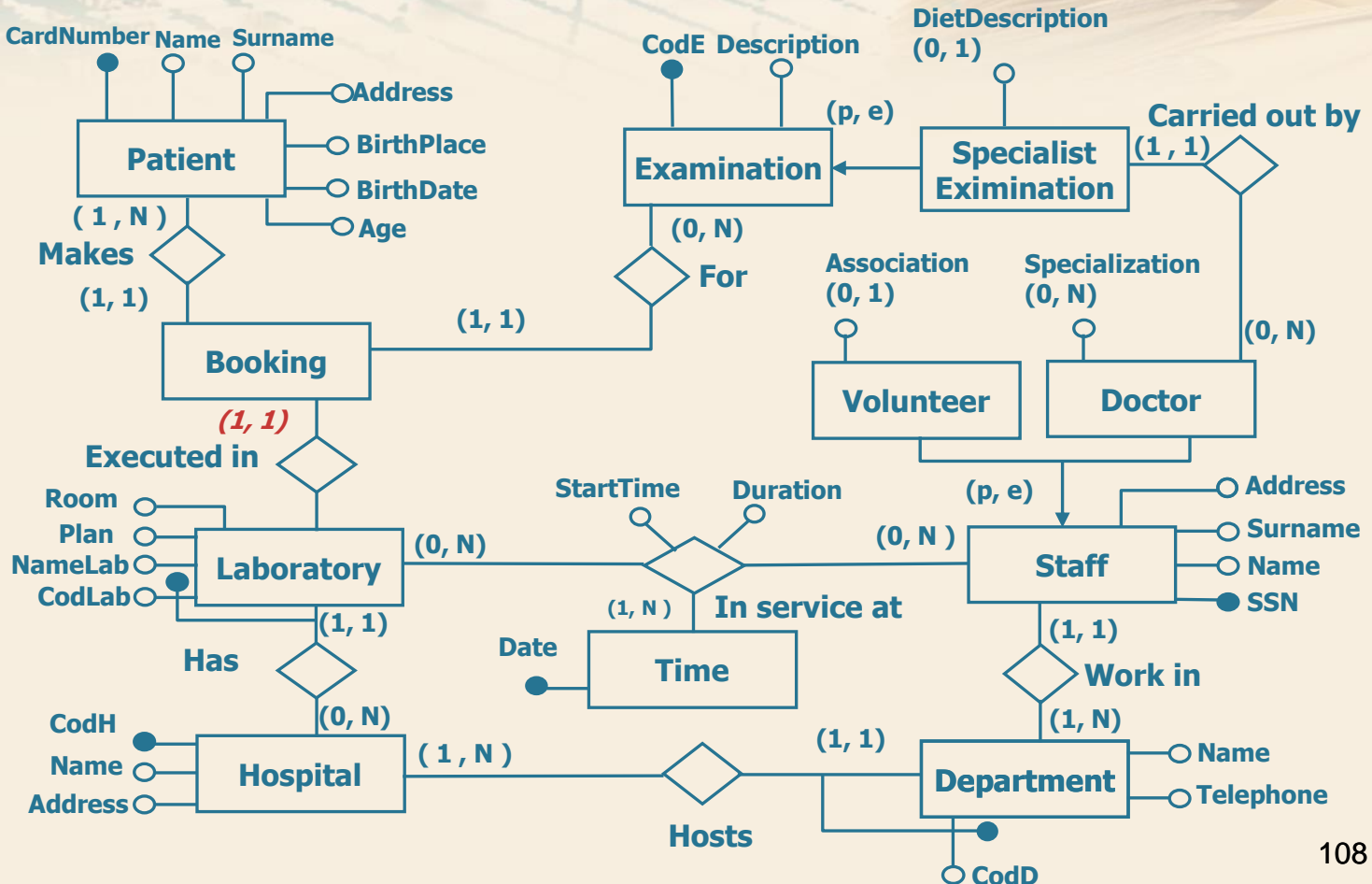
Cardinality of the For relationship



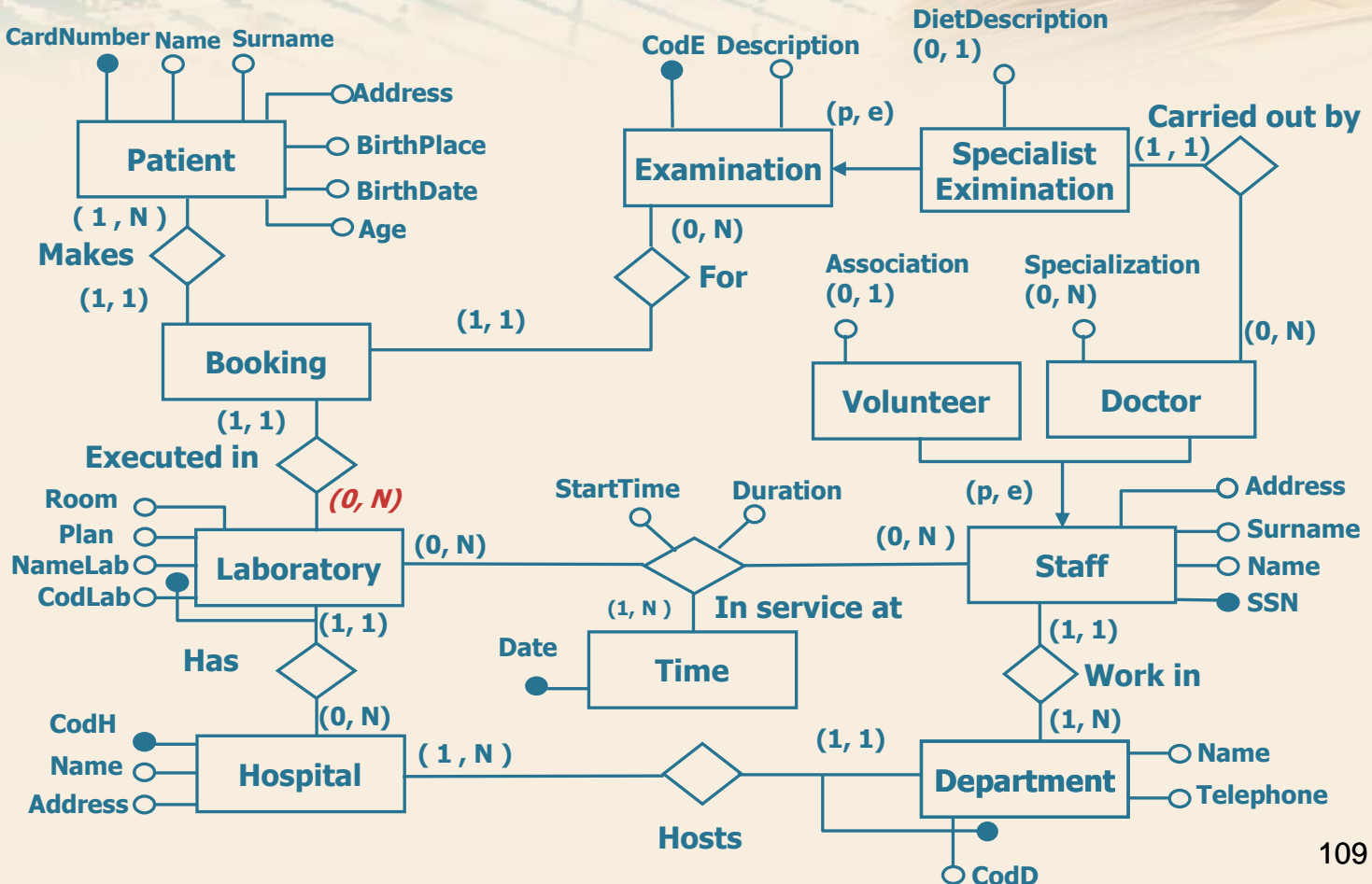
Relationship between Booking and Laboratory



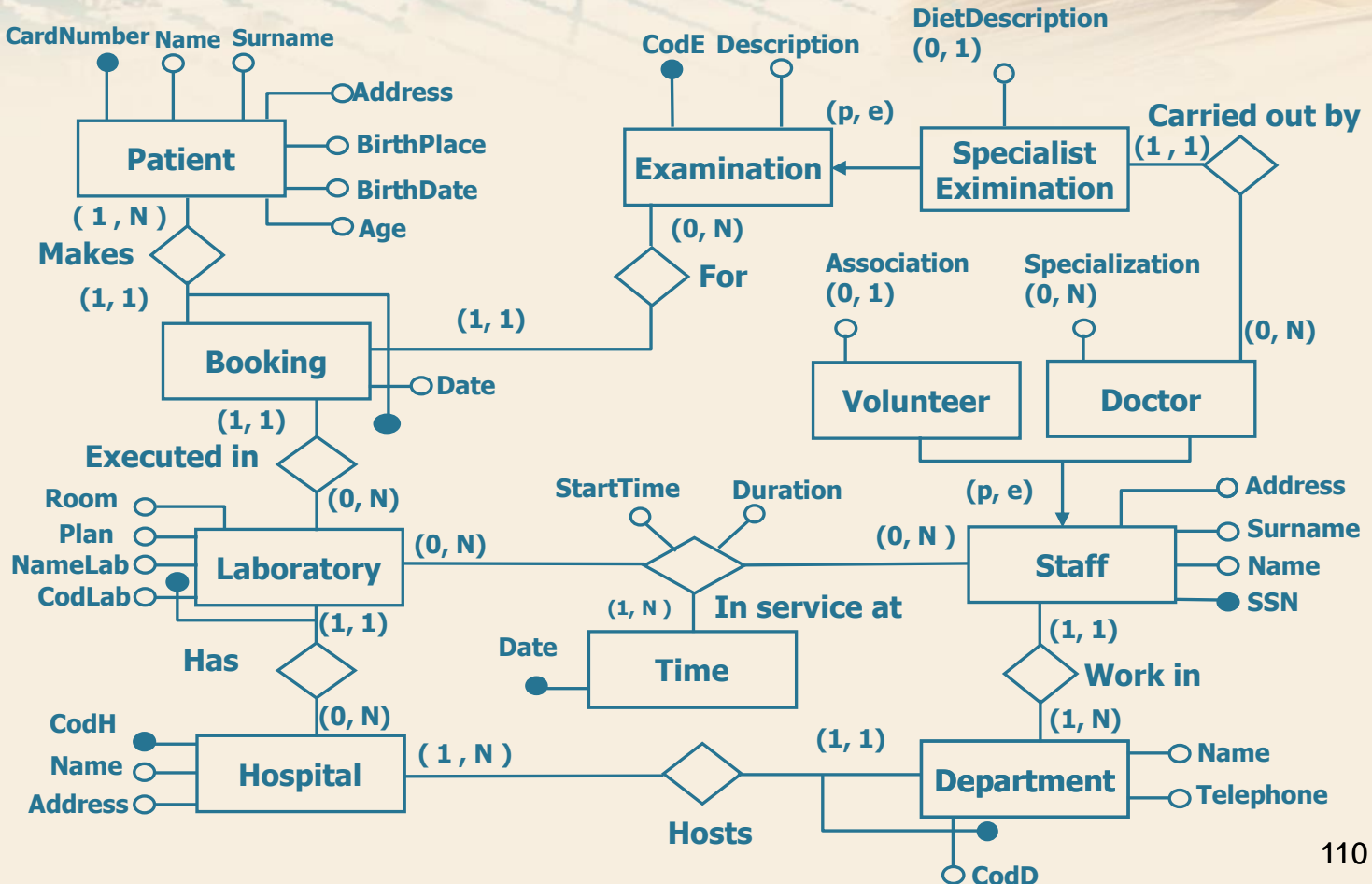
Cardinality of the Executed in relationship



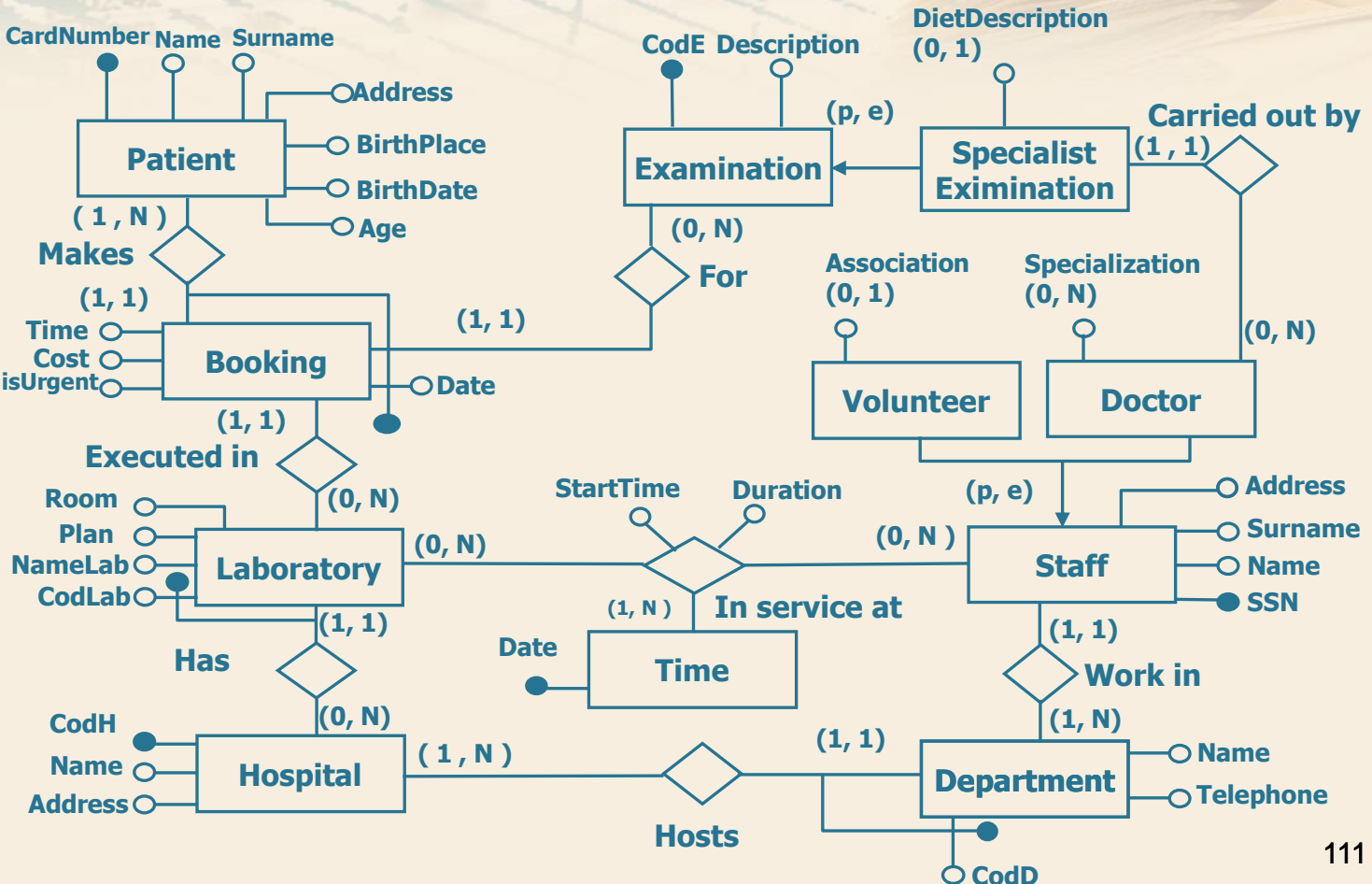
Cardinality of the Executed in relationship



Booking entity identifier



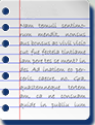
Refinement of the Booking entity





Conceptual design – time III

Relationship between Doctor and Role

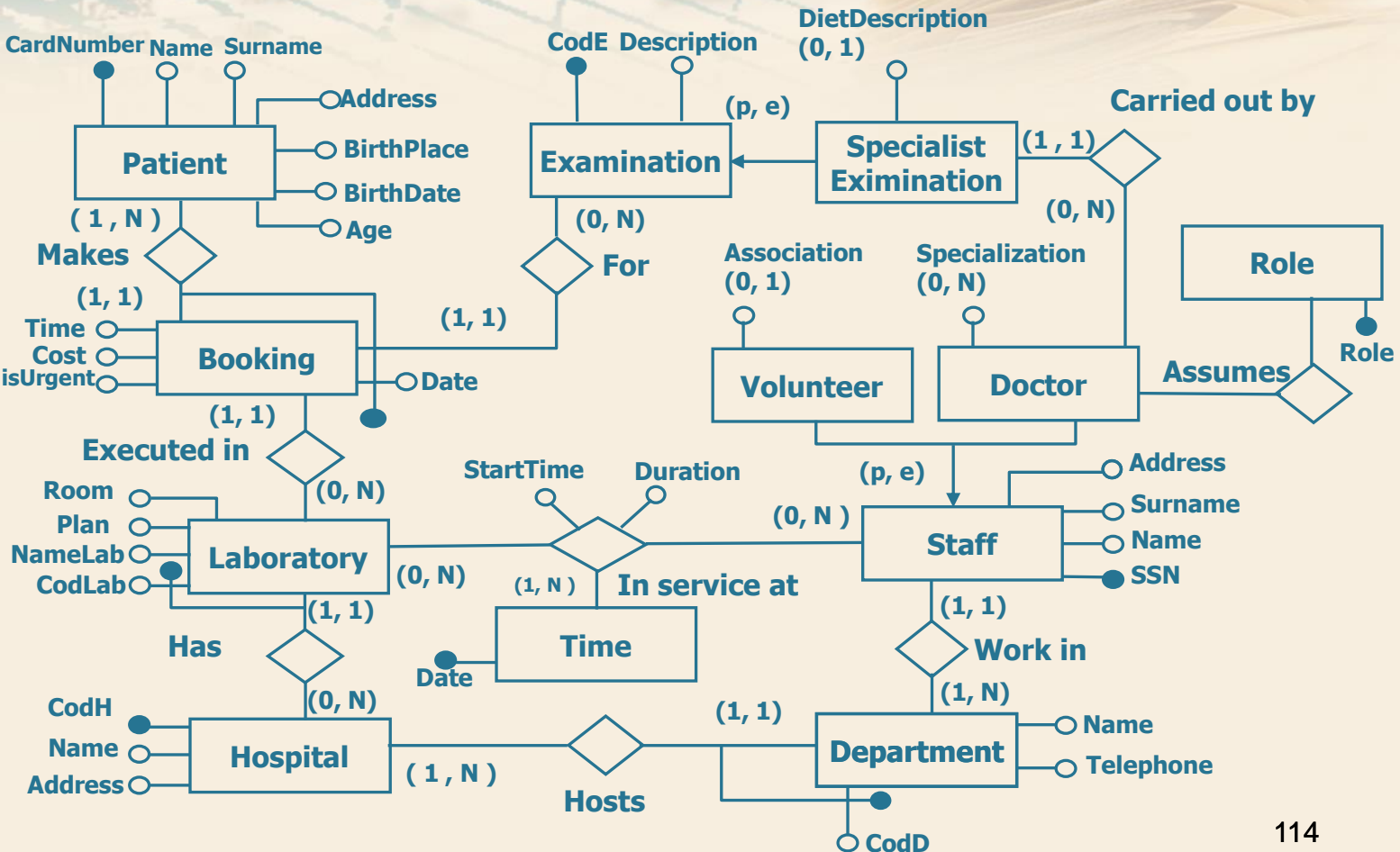


Each doctor can take on different roles during his career (e.g. assistant, head physician, etc.).

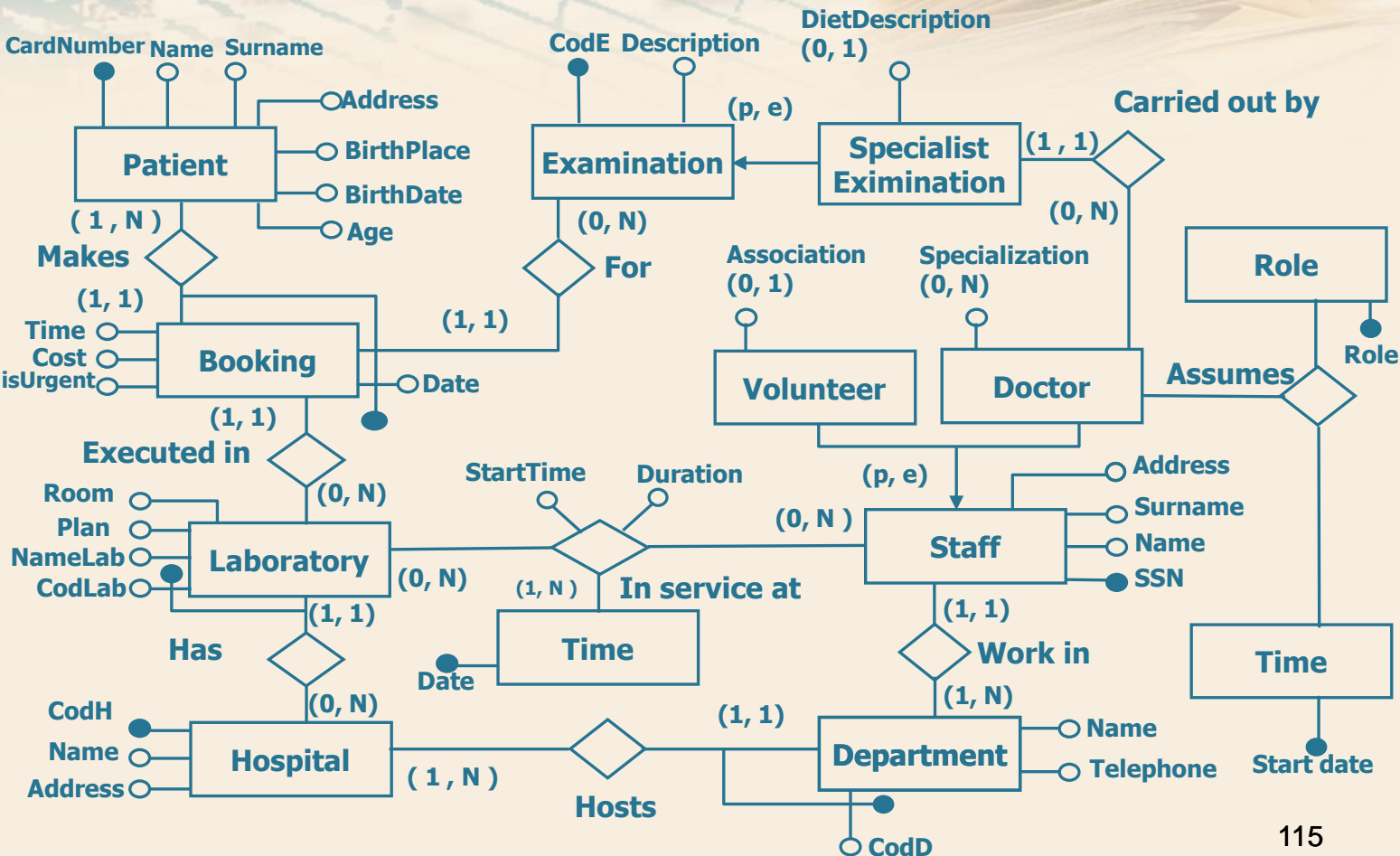
We want to keep track of the roles each doctor has taken on during his career and the related time periods (start date, end date).

Keep in mind that each doctor cannot take on more than one role at the same time, but he can take on the same role in different time periods.

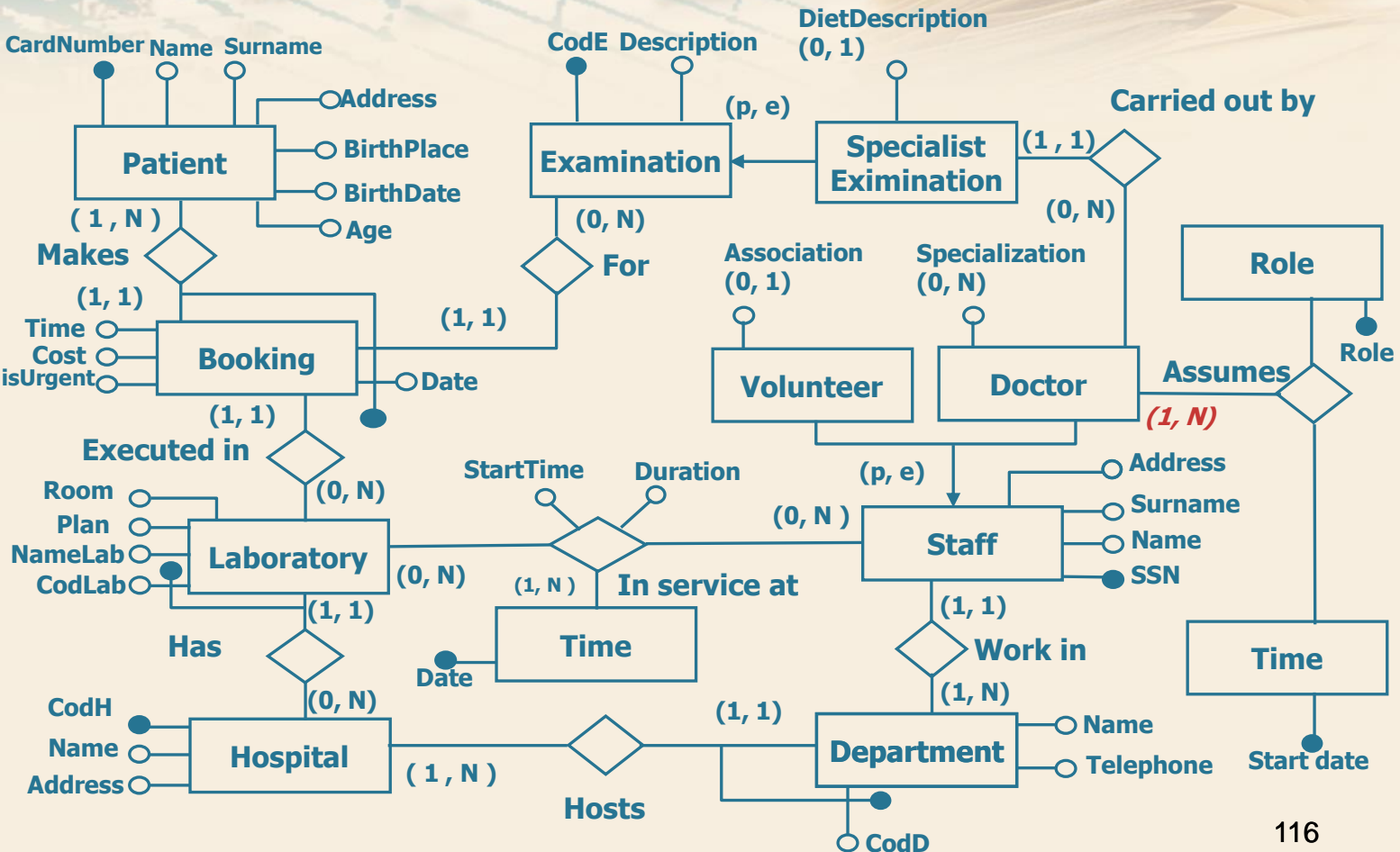
Relationship between Doctor and Role



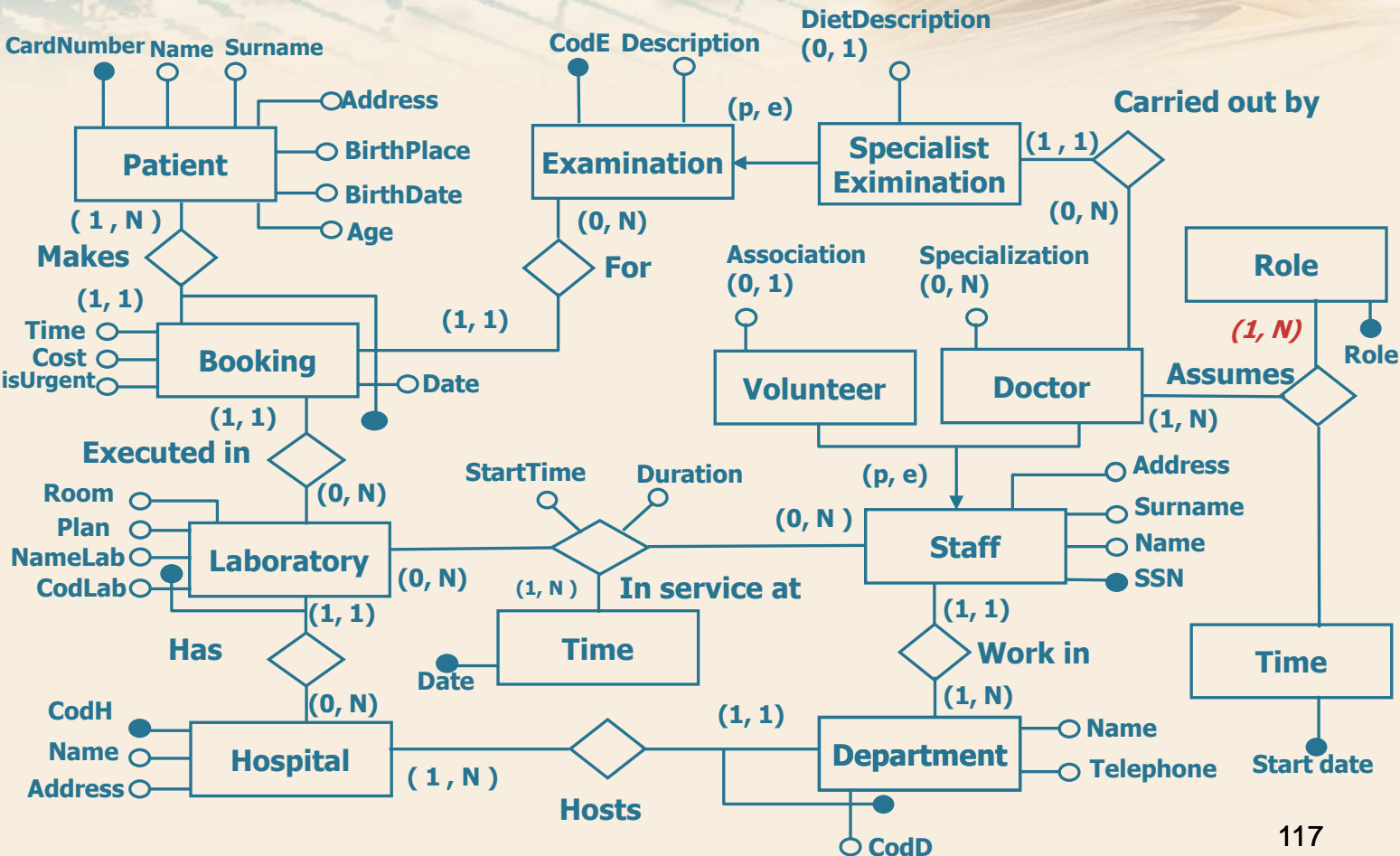
Historicization of the Assumes relationship



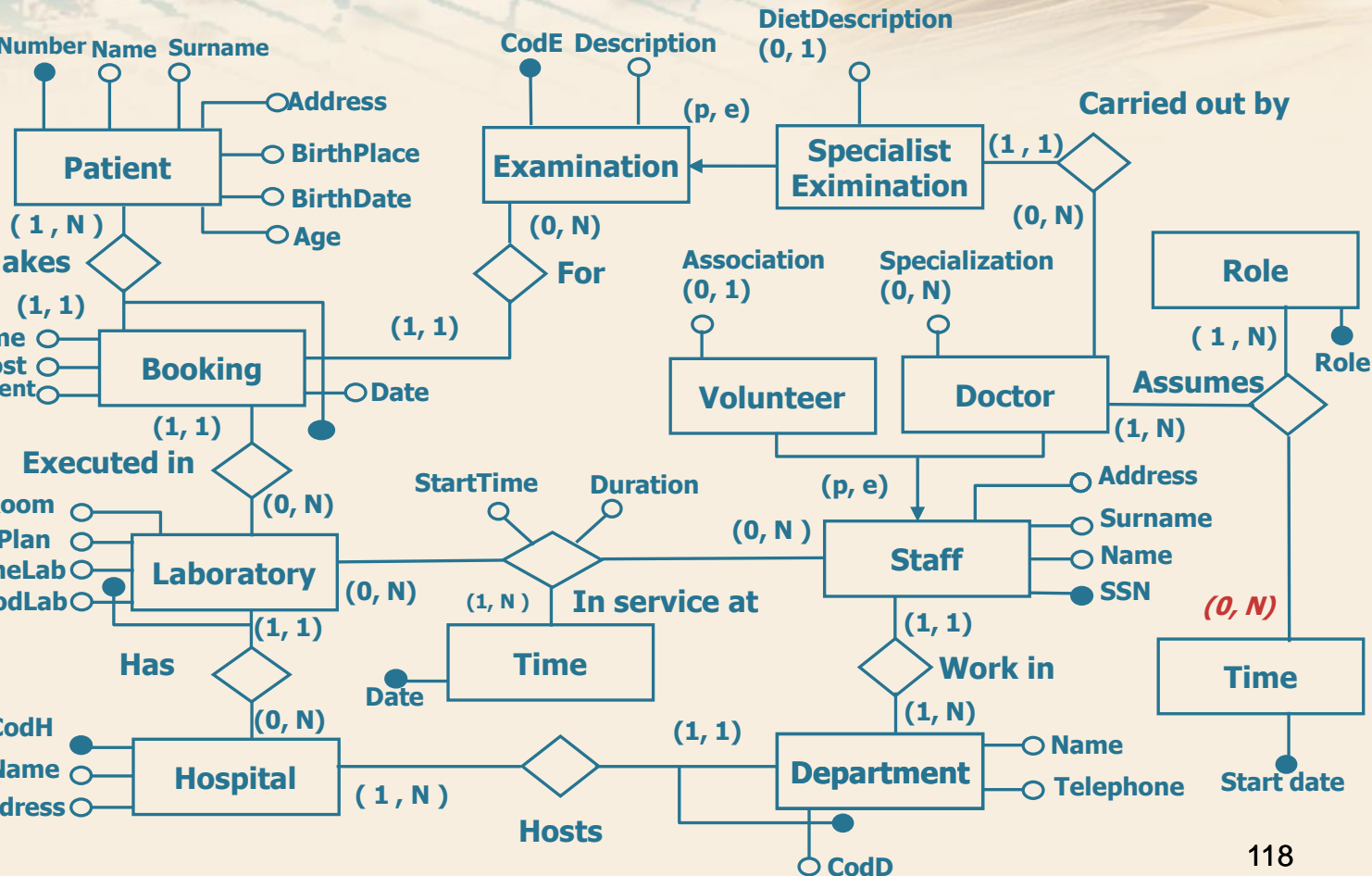
Cardinality of the Assumes relationship



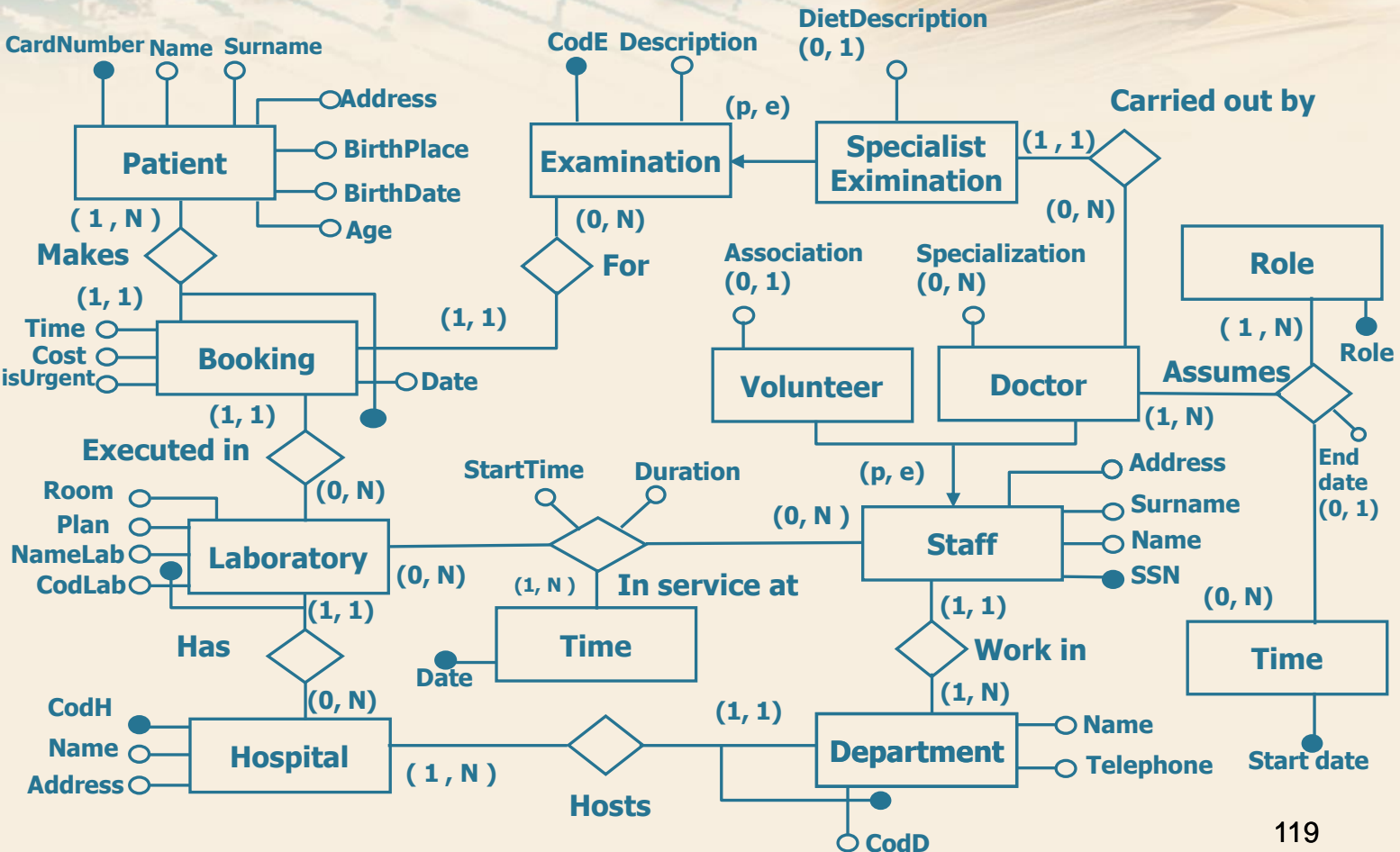
Cardinality of the Assumes relationship



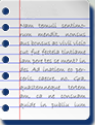
Cardinality of the Assumes relationship



Refinement of the Assumes relationship



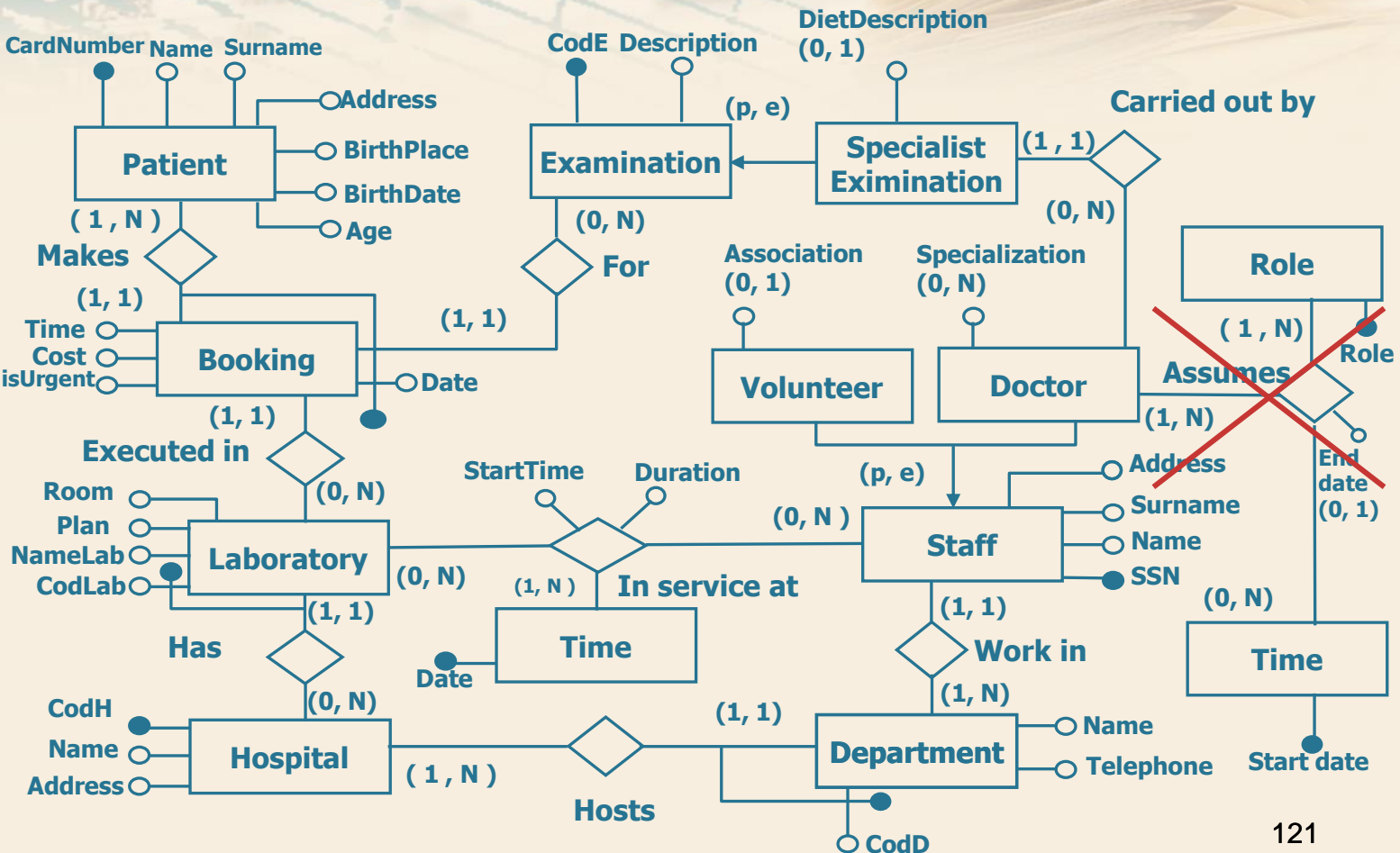
Constraints on the Assumes relationship



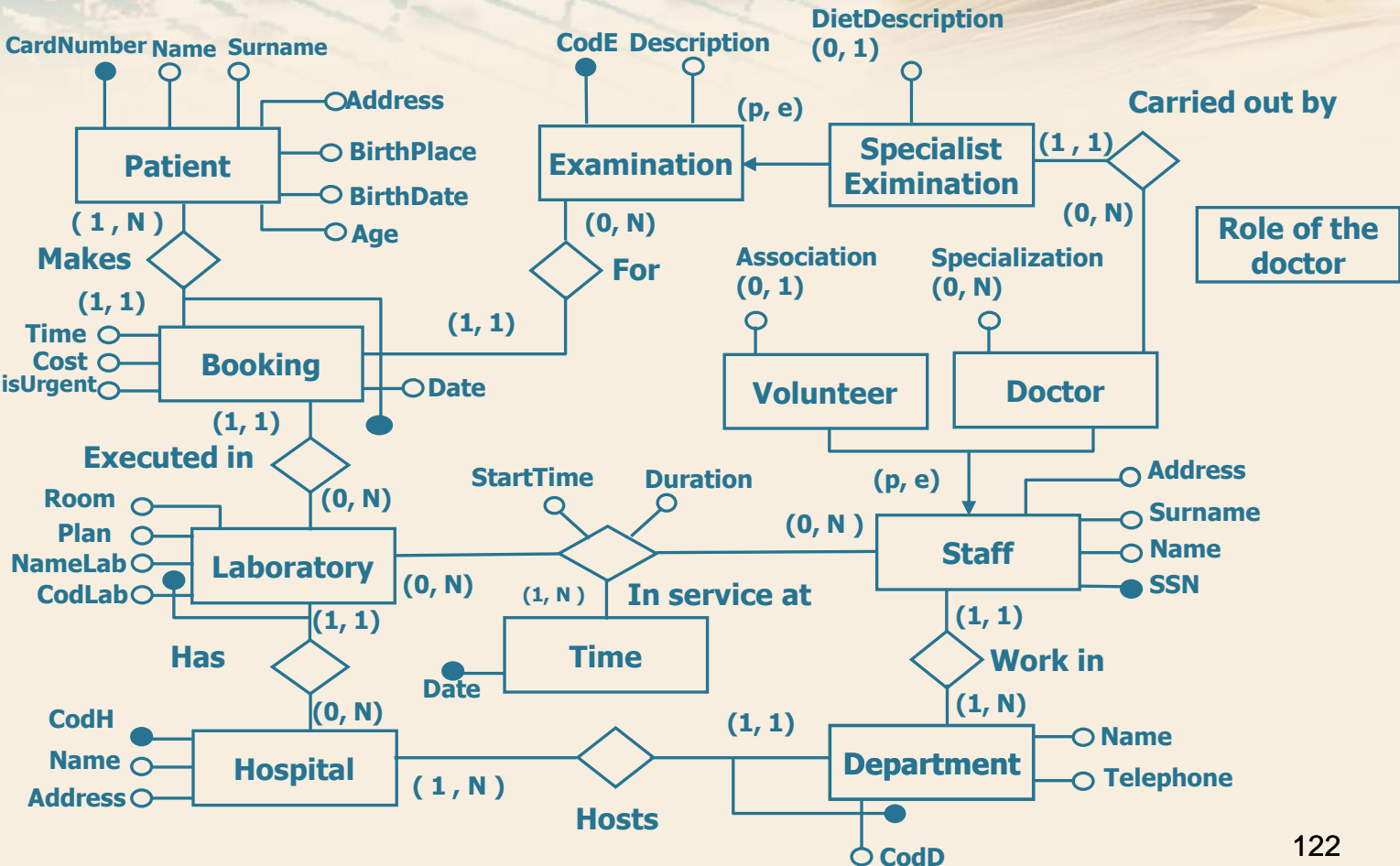
Each doctor can take on different roles during his career (e.g. assistant, head physician, etc.). We want to keep track of the roles each doctor has taken on during his career and the related time periods (start date, end date).

Keep in mind that each doctor cannot take on more than one role at the same time, but he can take on the same role in different time periods.

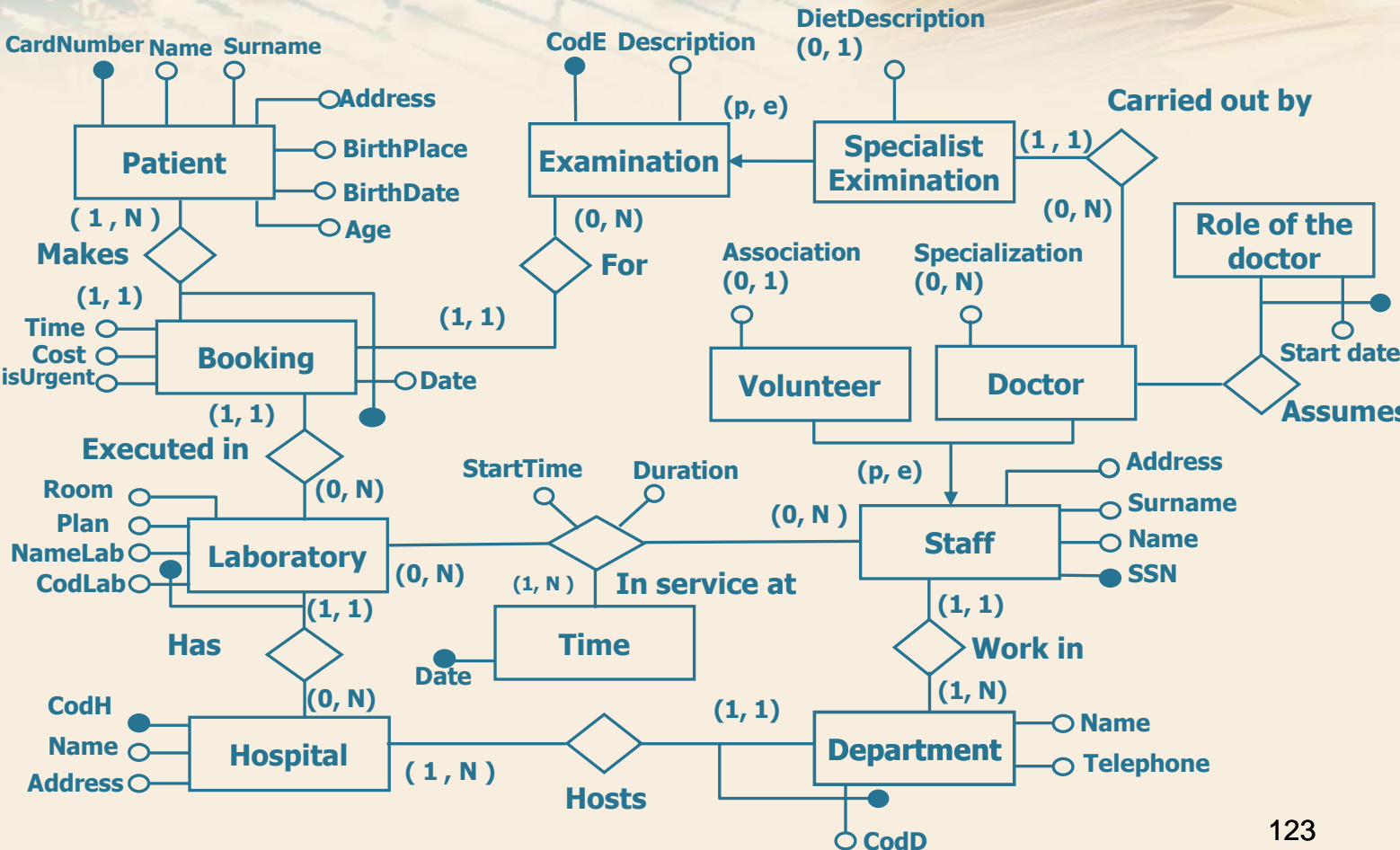
Historicization of the Assumes relationship



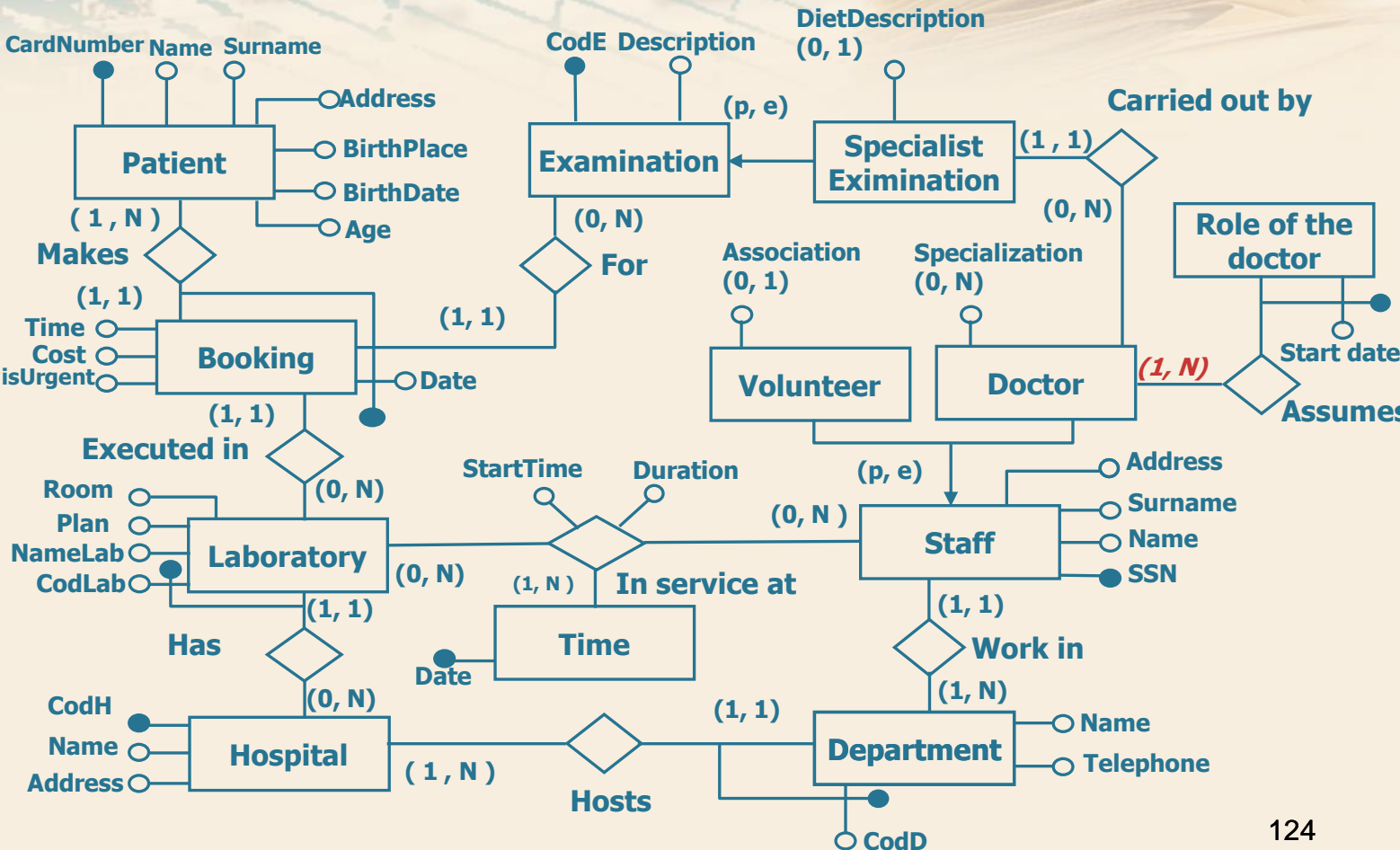
Introduction of the Role of the doctor entity



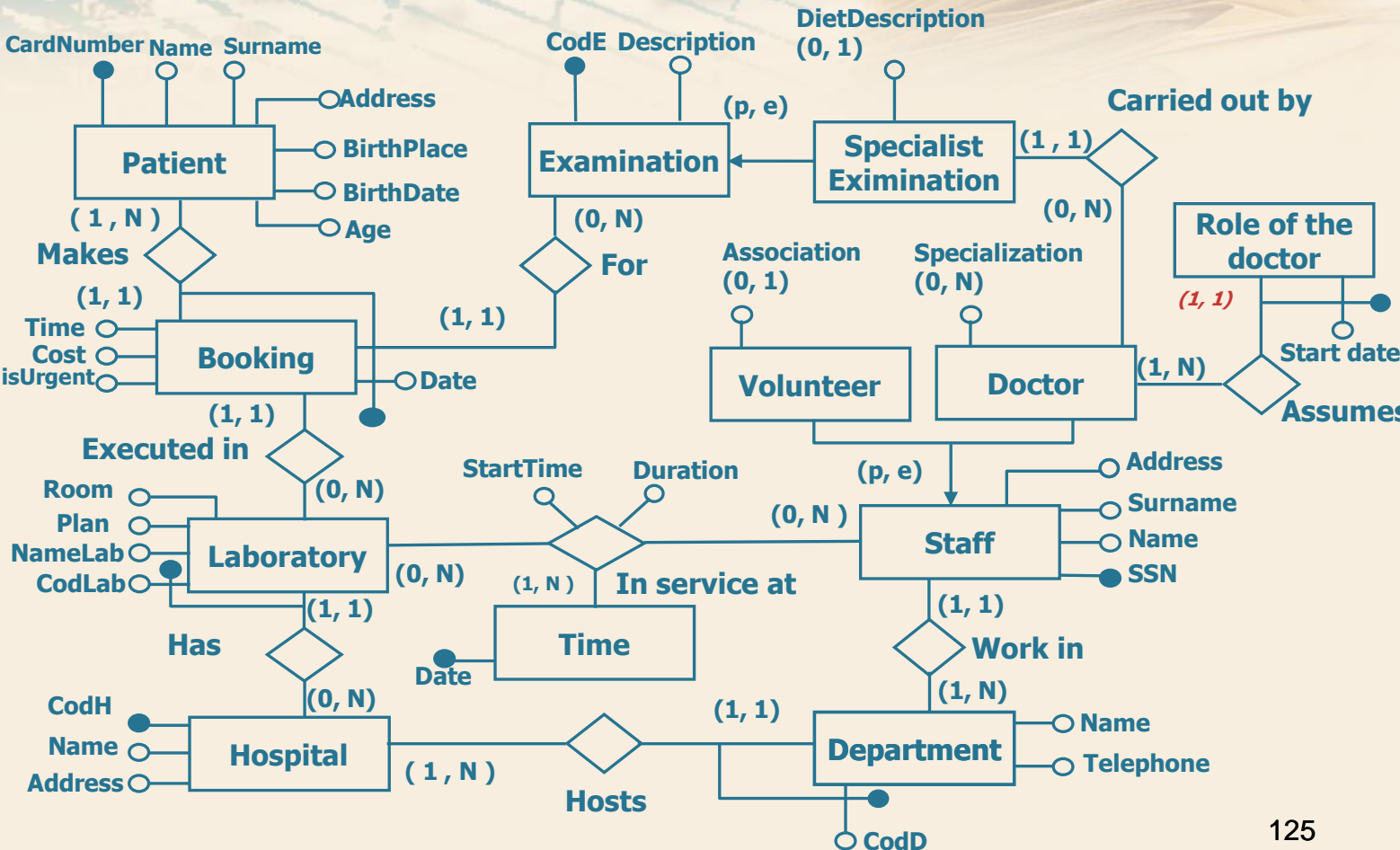
Historicization of the Role of the doctor



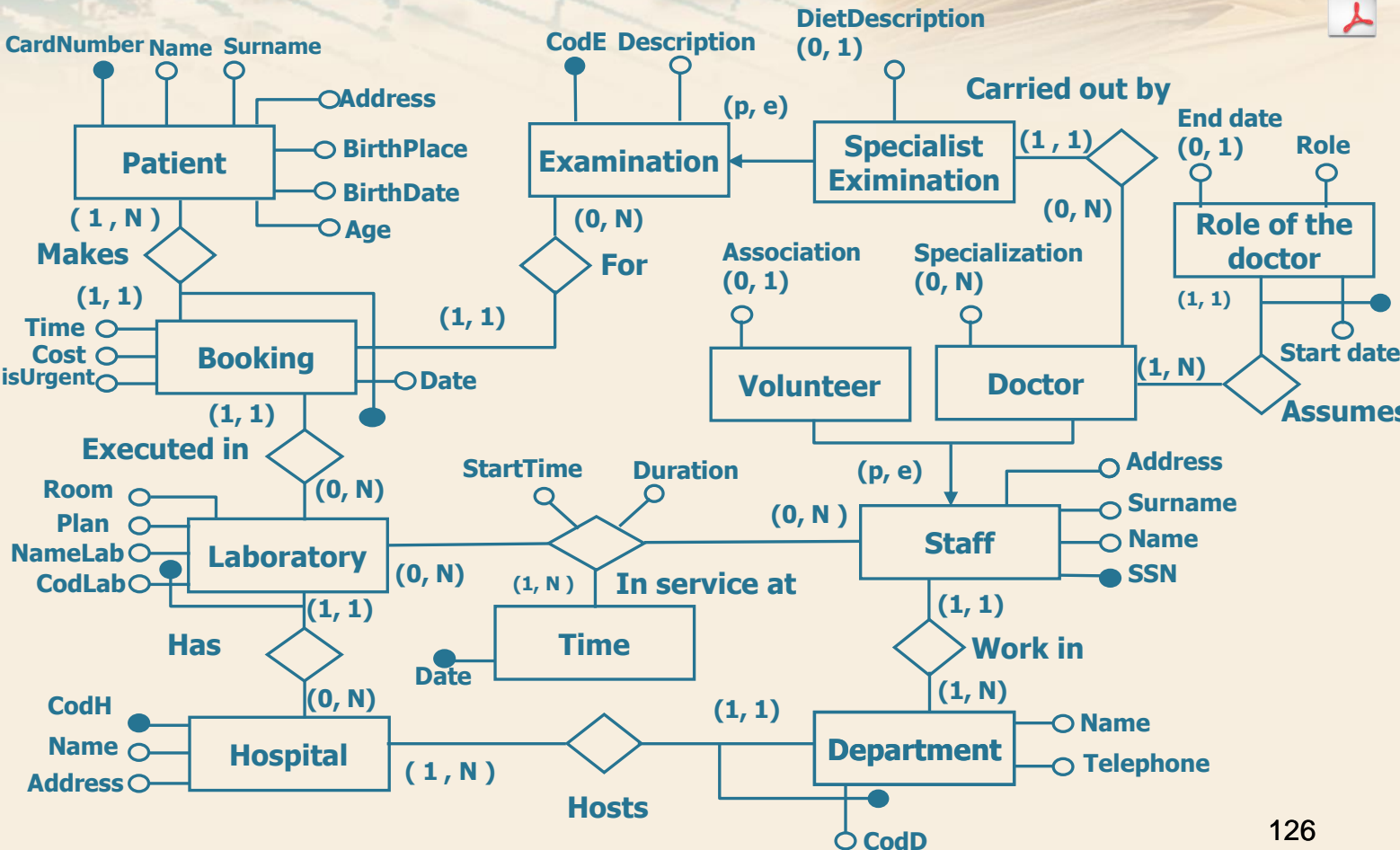
Cardinality of the Assumes relationship



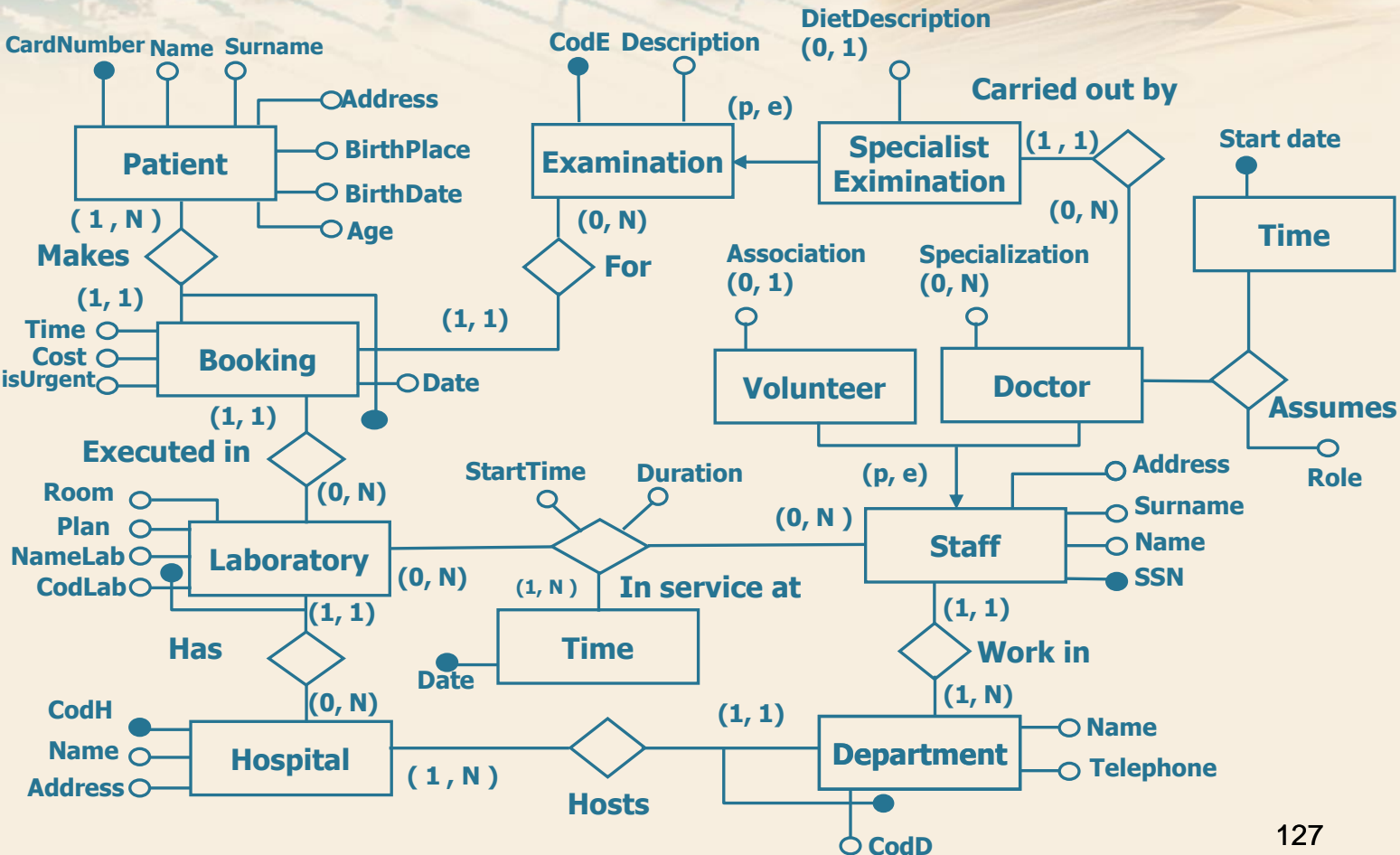
Cardinality of the Assumes relationship



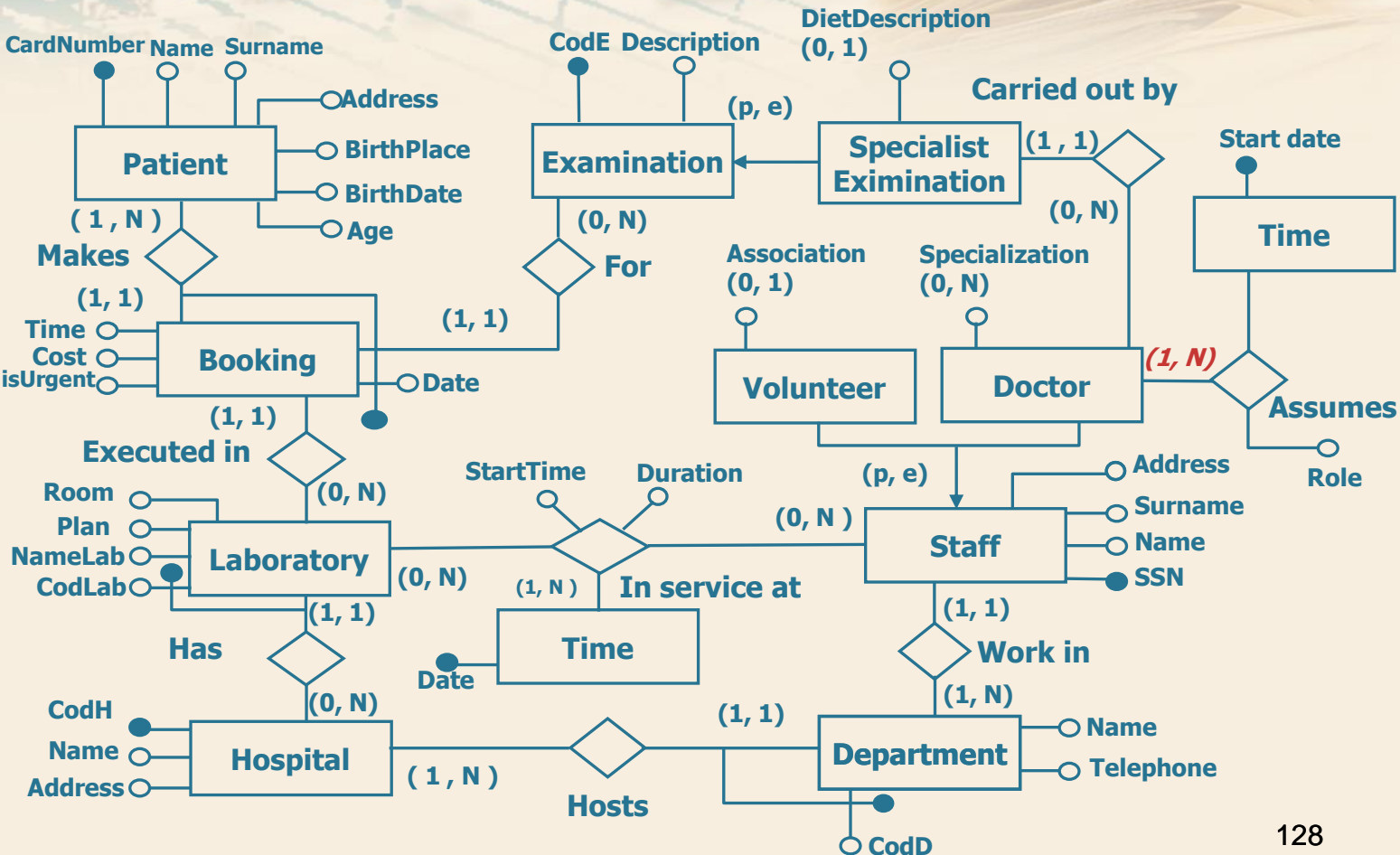
Refinement of the Role of the doctor entity



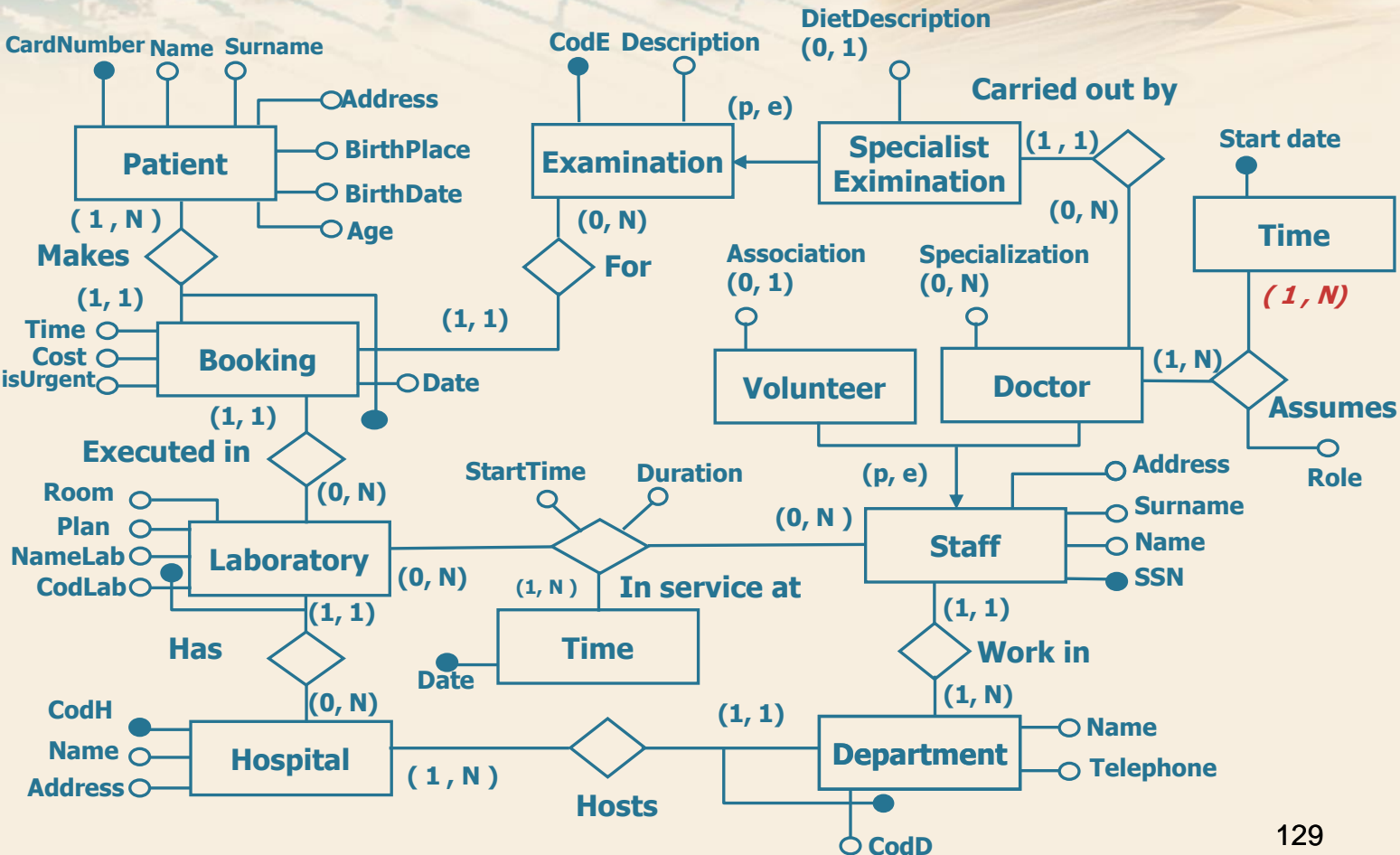
Role history: alternative



Cardinality of the Assumes relationship



Cardinality of the Assumes relationship



Cardinality of the Assumes relationship

