Winter 1-31-1994

Graphical OODB modeling for medical information standards (GOMMIS)

Jiping Liu
New Jersey Institute of Technology

Copyright Warning & Restrictions

The copyright law of the United States (Title 17, United States Code) governs the making of photocopies or other reproductions of copyrighted material.

Under certain conditions specified in the law, libraries and archives are authorized to furnish a photocopy or other reproduction. One of these specified conditions is that the photocopy or reproduction is not to be "used for any purpose other than private study, scholarship, or research." If a, user makes a request for, or later uses, a photocopy or reproduction for purposes in excess of "fair use" that user may be liable for copyright infringement,

This institution reserves the right to refuse to accept a copying order if, in its judgment, fulfillment of the order would involve violation of copyright law.

Please Note: The author retains the copyright while the New Jersey Institute of Technology reserves the right to distribute this thesis or dissertation

Printing note: If you do not wish to print this page, then select "Pages from: first page # to: last page #" on the print dialog screen

ABSTRACT

Graphical OODB Modeling for Medical Information Standards (GOMMIS)

by
Jiping Liu

The graphical representation of database schemata has been a useful tool for the designer and users of database systems. Such a tool for OODB schemata should incorporate a wide variety of symbols which cover most concepts of existing Object-Oriented Database (OODB) , so it is sufficient to support a diverse group of object-oriented data models.

In this paper we created a graphical representation, using the OOdini system and language, of the European Prestandard for Medical Informatics on Message Exchange of Laboratory Information. This European Prestandard describes a standardized format for messages to be exchanged between a health care provider and a medical laboratory. We have converted this medical information into graphical representation for OODB, and our graphical representation shows the connections between all the classes and the connections between classes and attributes. We have also displayed our graphical representation in three levels of abridgement, one of which allows the user to see only the class hierarchy.

The OOdini system which has been chosen to create and manipulate our graphical representation is discussed. This graphical editor gives us the power and flexibility to manipulate the class information at will.

GRAPHICAL OODB MODELING FOR MEDICAL INFORMATION STANDARDS (GOMMIS)

by
Jiping Liu

A Thesis
Submitted to the Faculty of
New Jersey Institute of Technology
in Partial Fulfillment of the Requirements for the Degree of
Master of Science in Computer and Information Science

Department of Computer and Information Science

Janurary 1994

APPROVAL PAGE

GRAPHICAL OODB MODELING FOR MEDICAL INFORMATION STANDARDS (GOMMIS)

Jiping Liu

Dr. Yehoshua Perl, Thesis Advisor — Date
Professor of Computer and Information Science, NJIT

Dr. David Wang, Committee Member — Date
Assistant Professor of Computer and Information Science, NJIT

Dr. Jason Wang, Committee Member — Date
Assistant Professor of Computer and Information Science, NJIT

BIOGRAPHICAL SKETCH

Author: Jiping Liu

Degree: Master of Science in Computer and Information Science

Date: January 1994

Undergraduate and Graduate Education:

- Master of Science in Computer Science,
  New Jersey Institute of Technology, Newark, NJ, 1994
- Bachelor of Science in Electrical Engineering,
  Fudan University, Shanghai, China, 1983

Major: Computer Science

ACKNOWLEDGMENT

I would like to express my sincere gratitude to my advisor, Prof. Yehoshua Perl, CIS Department, NJIT, for his friendly advice and invaluable guidance and contributions throughout this thesis. I would like to thank my committee members, Dr. David Wang and Dr. Jason Wang, for all good suggestions they made regarding this thesis.

Aruna Kolla deserves much credit for her technical and moral support throughout this work. Despite her busy schedule she spent enormous amounts of time discussing various aspects of the project which has made this work possible.

I would like to thank all the members of our research group, those who have participated in the development of OODINI.

I also extend our sincere thanks to the Chairman and Faculty of the Computer Science Department.

Last but not the least, I want to thank all my friends who encouraged me and those who gave tips which helped me to complete this work.

TABLE OF CONTENTS

Chapter Page

CHAPTER 1

INTRODUCTION

1.1 Motivation

The graphical representation of database schemata has been a useful tool for the designers and users of OODB systems. Such a tool incorporates a wide variety of symbols including those for classes, attributes, methods, user-defined relationships, constraint relationships, and generic (system-defined) relationships enough to support a diverse group of object-oriented data models.

In this paper, we created a graphical representation, using the OOdini system and language, of the European Prestandard for Medical Informatics on Message Exchange of Laboratory Information [1]. This is a document that describes a standardized format for messages to be exchanged between a health care provider and a medical laboratory.

The prestandard represents important information in a very disconnected way. some kinds of information are not only physically separated from the others, but they are even represented in a different, non-graphical formalism. This is irritating in that it forces the reader to leaf back and forth through the document just for answering a simple question. It also does not make full use of the power of the graphical representation. Also the graphical parts are given mostly as separate figures and thus lack context.

OOdini [2] is a graphical editor for object-oriented schemas that was developed at NJIT during the past three years. OOdini features a powerful set of icons that cover most concepts of existing Object-Oriented Database (OODB) systems. Our GOMMIS system creates one single large graphical representation that shows the connections among all the classes and also the connections between classes

and attributes. The electronic representation gives us the power and flexibility to manipulate the class information at will. Furthermore, the graphical representation will serve as a starting point in our planned future work with local databases. Our project achieved its main purpose of demonstrating that graphical OODB display of medical informatics improves dramatically the possibilities to comprehend a complex application.

1.2 General Approach

Following [3], the characteristics of OODB systems are the notions of objects and classes. A class can be regarded as a container for objects which are similar in their structure and semantics in the application. To describe the structure and semantics of objects, the class uses four kinds of properties:

1. Attributes - values of a given data type.
2. User-defined relationships - named references to other classes.
3. Methods - operations which can be applied to instances of a given class.
4. Generic relationships - similar to relationships in that they are references to other classes; however, these are system-defined, while relationships are user-defined.

The basis for a graphical language is the labeled, directed graph, where both vertices and edges are labeled. The vertex labels allow us to represent the different kinds of classes. Similarly, the edge labels permit the representation of the various generic and user-defined relationships, and path methods.

A graphical language editor, such as OOdini, incorporates a set of symbols to represent classes, attributes, methods, user-defined relationships, constraint relationships, and generic (system-defined) relationships. Such an editor allows the

user to interactively manipulate the graphical schema representation for OODBs defined above.

For a summary of all these symbols in OOdini, please see the table in Figure 1.1. The rest of this paper is organized as follows. The European Prestandard for Medical Informatics on Message Exchange of Laboratory Information is briefly introduced in the chapter 2. Chapter 3 gives a quick tour of the OOdini system which implements the graphical representation. Our GOMMIS system is extensively discussed in Chapter 4, and the results are summarized in Chapter 5.

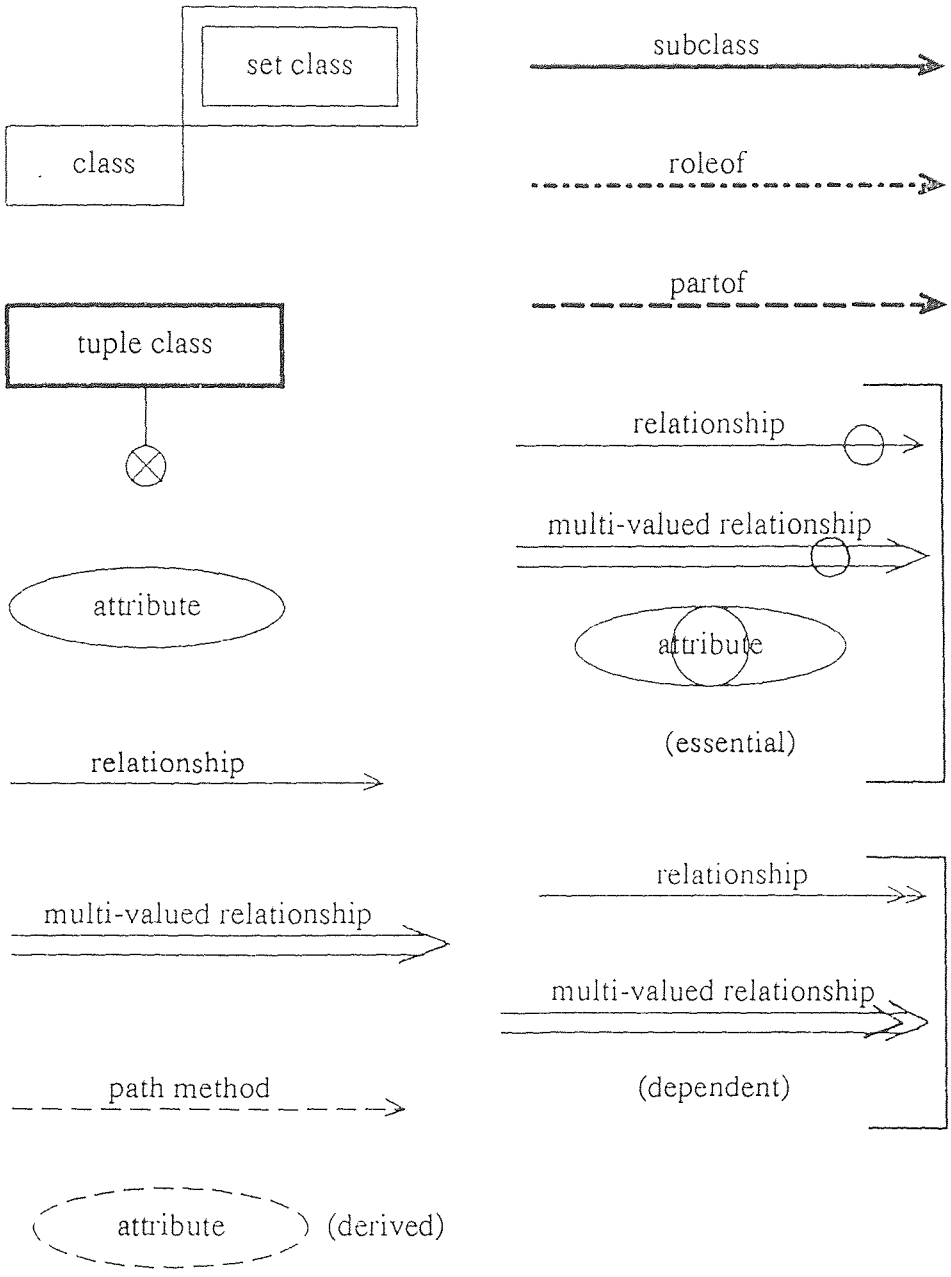

Figure 1.1 The graphical schema symbols

CHAPTER 2

EUROPEAN PRESTANDARD

The increased use of data processing and telecommunications capabilities has made possible the interchange of information in machine readable and processable formats. As automated interchange of information in health care increases, it is essential to provide appropriate information interchange standards.

Clinical laboratories carry out investigations requested by health care parties and send the results of theses investigations to the requester and sometimes to others.

Computer systems are in use for the store and processing of information in many clinical laboratories. Similarly many of the requesters of investigations or recipients of reports use other computer systems to store and process information. This information includes details of investigations requested and results received. Standards are required to facilitate electronic transfer of requests for and results of investigations between the many systems currently used.

Implementation of this European Prestandard will therefore:

- facilitate the electronic transfer of orders for investigation from requesting health care parties, to clinical laboratories;
- facilitate the electronic transfer of reports from clinical laboratories to requesters and other interested health care parties.
- reduce the need for human intervention in information interchange between applications used by clinical laboratories and those used by other health care parties.

2.1 Scope

This European Prestandard describes general messages to be used for electronic information interchange between computer systems in clinical laboratories and computer systems used by health care parties requesting the services of, or receiving results from, clinical laboratories.

Clinical laboratories are subdivided into specialties in different ways in accordance with different national or local practices. The health care party communicating with the clinical laboratory may be either a person such as a doctor or an organization such as a hospital, clinic or department.

The scope of the messages specified by this European Prestandard includes requests and results related to investigations provided by clinical laboratories on subjects of investigation. The scope includes requests related to samples that are obtained at the point of care or at any other specified location and submitted to the clinical laboratory. It also covers requests for investigations for which the laboratory is requested to obtain samples.

The request messages specified cover requests for investigations, modifications of requests for investigation and cancellation of requests for investigation. The report messages specified cover reports of the results of investigation, modifications of previously issued reports (either to extend, complete or correct previously reported results) and cancellations of previously issued reports.

2.2 Format

The European Prestandard document consists of three major parts:

1. A list of definitions and explanations of medical terms, elaborated by examples.

2. A description of Domain Information Models involved in the medical messages. These messages are defined by a set of classes representing medical terms, and

their interconnections, using a common formalism, due to P. Coad and E. Yourdan [4], for objected-oriented analysis.

3. A large set of tables that describe the applicability of attributes to the classes mentioned in the first part. Every attribute is assigned a code of Mandatory, Optional, or Not Applicable relative to six main types of messages that laboratories are bound to send or receive.

CHAPTER 3

A TOUR OF THE OODINI SYSTEM

OOdini (Object-Oriented diagrams, New Jersey Institute of Technology) is a constrain-based graphical editor which allows the user to interactively manipulate the graphical schema representation for OODBs. The system is implemented on a Sun 4/20 workstation. Graphical and interface support are provided by X, the X Toolkit (Xt), and the Motif widget set. OOdini's main screen can be seen in Figure 3.1.

As with most software systems built on top of Xt, OOdini relies heavily on the mouse for interaction with the user. The keyboard is required occasionally in response to a dialog box to input textual data, such as the name of a class. The interaction with OOdini during schema creation follows a regular pattern: The user selects a symbol, such as a class or a relationship, from a RadioBox widget and then proceeds to add any number of instances of that symbol to the schema. When finished with this "current" symbol, the user chooses another and further expands the schema. This process continues until the schema is completed.

OOdini fits into the Motif working environment, the main system screen is laid out with the preferred menu bar and work area arrangement. At the uppermost portion of the main window is the menu bar which contains the normal array of entries, "File", "Edit", "Option", and "View".

The File entry drops down a menu giving the user access to a number of disk storage and retrieval commands. Of note is the command to print the entire current screen to disk in a Postscript (PS) format.

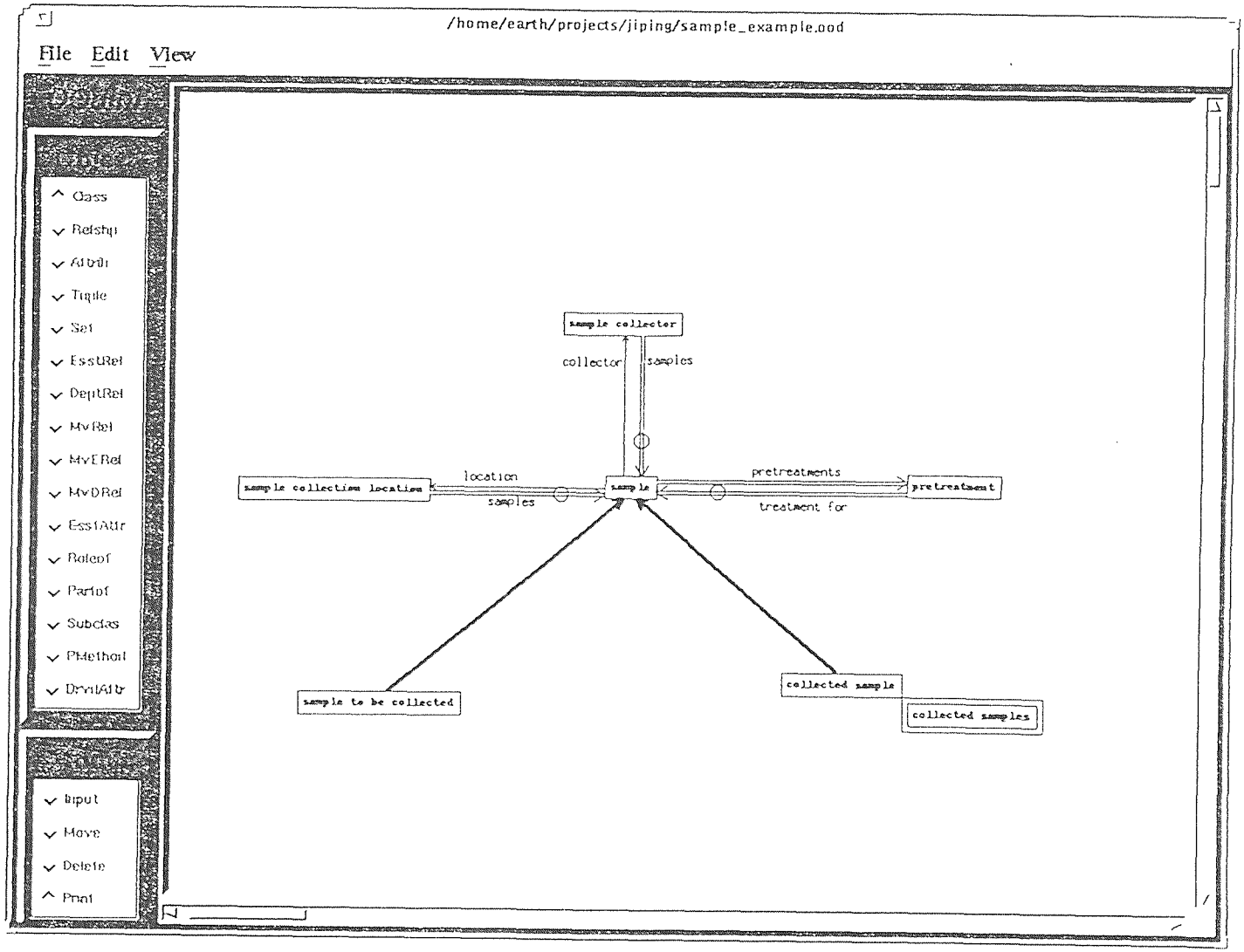

Figure 3.1 OOdini's main screen

The View entry provides three levels of display for a graphical representation. These levels are characterized by:

1. no omissions.

2. omission of attributes and local methods, except for those which participate in path methods.

3. omission of all attributes, relationships, and methods, leaving only the classes, and hierarchical and membership generic relationships.

The Edit menu provides the user with a search feature for tracking down a desired class. This function positions the system's current working window around a given class.

CHAPTER 4

OODB GRAPHICAL REPRESENTATION

We are now ready to discuss our integrated graphical representation, using the OOdini system and language, of the European Prestandard for Medical Informatics on Message Exchange of Laboratory Information. The European prestandard could be divided into four relatively independent parts, they are laboratory service order and report, subject of investigation, sample, and healthcare party. In this chapter, we first explain these four parts. Later, we briefly discuss our integrated graphical representation.

4.1 Laboratory Service Order and Report

Figure 4.1 shows the domain of laboratory service order and laboratory service report in second display level. Both laboratory service order and laboratory service report are general message descriptions. This subschema describes the relationships between the communication systems and the general message descriptions, as well as relationships among the general message descriptions.

4.1.1 Laboratory Service Order

As we can see an order is issued to the laboratory by a requester. The requester is a healthcare party which in turn can be a healthcare professional or a healthcare organization.

The order is received by a laboratory service provider. This is a person or an organization qualified to perform the required measurements and issue a report.

As a general message description, the order includes information as follows:

1. Subject of investigation

   This includes all the data necessary to identify the subject of investigation (whether patient, animal or material). If the system is a patient, the order should include data about patient, the same for animal and material.

2. Sample

   This includes data such as the nature of the sample, sample preservation and transport conditions, data and time of collection, collection procedure, precautions, hazards etc. The sample can either have been collected by the requester, or instructions can be included in the order as to what sample should be collected by the laboratory or its agents and the location.

3. Requested investigation (s)

   The requested investigation(s) are assumed to be from a list of available investigations. An investigation can be an individual investigation such as sodium ion concentration or a group of investigations such as full blood count.

4. Intended recipient of report copy

   The requester may specify information as to when and to whom the report should be issued. This could include items such as:

   - Whether the requester requires a copy of the report
   - Whether copies of the report are required by any other healthcare party and if so their identities and locations.
   - Date and time by which the report is required

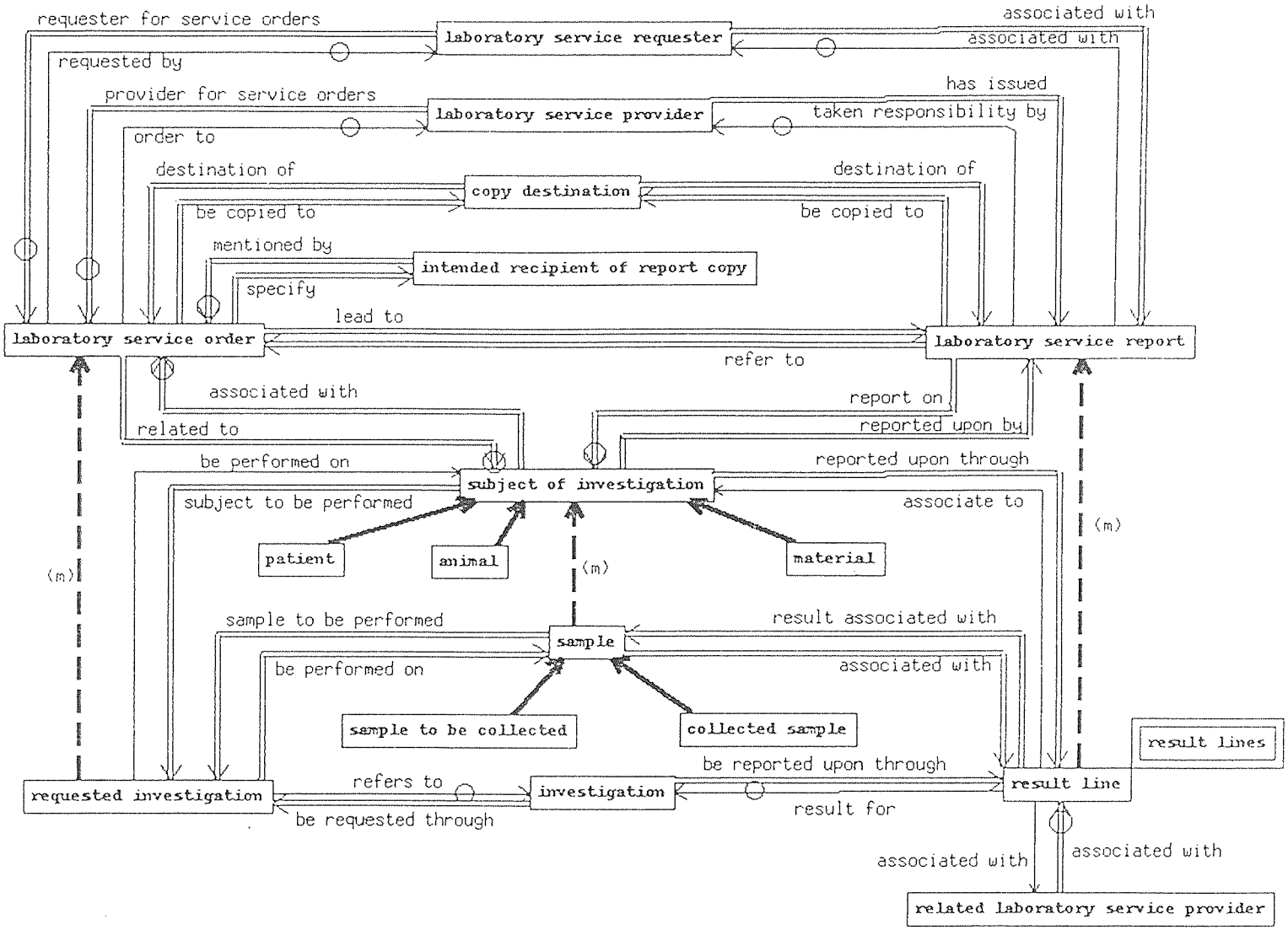

Figure 4.1 Laboratiry service order and report

Among the general message descriptions, the requested investigation is part of laboratory service order, which will be performed on either one subject of investigation or many samples. The subject of investigation could be specified into patient, animal or material. A sample, as a part of subject of investigation, is always either the sample to be collected or collected sample.

4.1.2 Laboratory Service Report

The laboratory service provider decides that there is result information which should be reported. This does not necessarily mean that the work is complete or that a complete report is available.

As a general message description, laboratory service report contains information on results of investigations for single or multiple subjects. As we can see in Figure 3, the report contains a set of result lines, one result line may contains a set of lower level result lines. Result line is describing results for investigations, and some result lines from related laboratory service providers are included in the report.

A report refers to zero or many laboratory service orders.

A report may be copied to zero or many copy destinations.

As a part of the intergated schema, figure 4.1 mainly appears on page 1 and 3 of Appendix A.

4.2 Subject of Investigation

We have mentioned that the subject of investigation is one kind of information in laboratory service order. In Figure 4.2 we further display the classes, relationships and attributes information in the domain of subject of investigation.

- A subject of investigation is specialized into either an animal, a patient or a material.

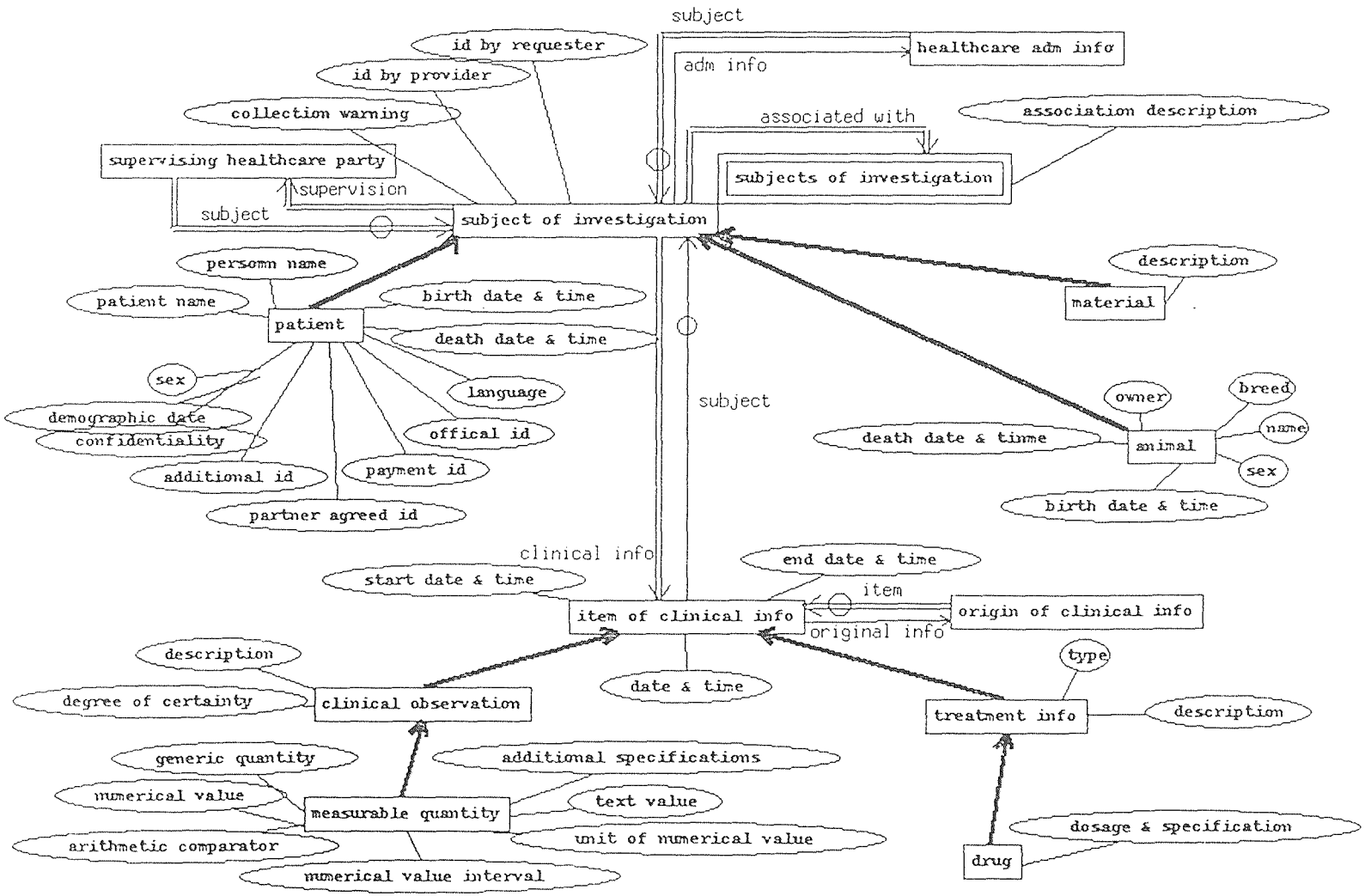

Figure 4.2 Subject of investigation

- A subject of investigation may be associated with other subjects of investigation.

- A subject of investigation may be specified by either zero or one instance of healthcare administrative information objects.

- A subject of investigation may be supervised by zero or many supervising healthcare parties.

- A subject of investigation may be specified by zero or many items of clinical information.

  The item of clinical information may optionally be associated with a single origin of clinical information.

  The item clinical information is always specialized into either a clinical observation or treatment information. A clinical observation in turn can be specialized into a measurable quantity whereas treatment information may be specialized into drug.

As a part of the integrated schema, figure 4.2 mainly appears on page 2 of Appendix A.

4.3 Sample

Figure 4.3 shows the domain of sample in first display level. As we have mentioned, sample is one kind of information of laboratory service order. In the relationships among general message descriptions, a sample is part of a subject of investigation, and a requested investigation is to be performed using either a subject of investigation or one or more samples.

In this subschema, we focus on sample, describe it more specifically. In Figure 4, a sample may be associated with a sample collector and a sample collection location.

Also sample may be specified by many Pretreatment actions which are taken before collecting sample. Sample itself has attributes which are:

- requester sample id: code value assigned by a laboratory service requester to a sample for its identification.
- provider sample id: code value assigned by a laboratory service provider to a sample for its identification.
- type: type of sample. e.g. urine, blood.
- anatomical origin: anatomical origin of sample. e.g. left knee.
- collection procedure: procedure(s) directly associated with the collection of a sample from the subject of investigation. e.g. aspiration, drainge.
- handling: action taken after the collection of a sample and the preparatory to measurement. e.g. air-dried, refrigerated.
- preservation material: container or medium in or on which a sample is conveyed from the point of collection to the lab and/or chemical that preserves the sample in a condition appropriate for contact after collection. e.g. plain glass, heparin.
- no of containers: number of containers for a given type of sample.

A sample is always specialized into either a sample to be collected or a collected sample. Both subclass sample to be collected and collected sample inherit the properties from their superclass sample, and their own have more specifical properties.

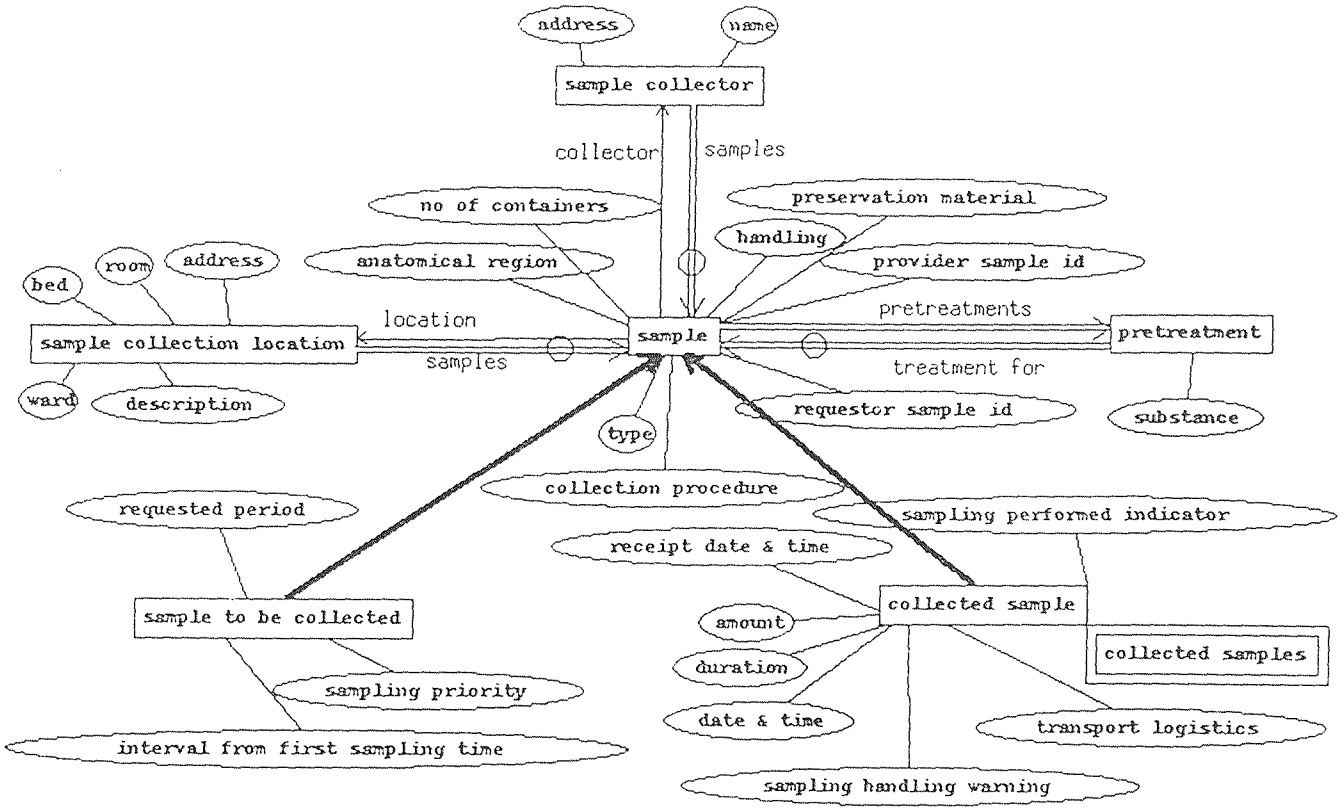

Figure 4.3 Sample

1. Collected sample

   collected sample specifies the characteristics applicable for a sample for which no sample collection service is requested from the laboratory service provider (e.g. sample is already collected, sample collector is not the laboratory service provider). Collected sample has the following attributes:

   - date and time: date and time of sample collection. e.g. 10:00 pm, 26 January 1993.
   - duration: duration of sample collection. e.g. 1(second), 8(hours).
   - transport logistics: means by which a sample reaches the laboratory. e.g. public postal service, routine transport van.
   - receipt date and time: date and time of receipt by the laboratory of a collected sample.
   - sample handling warning: warning of dangers that the sample presents to those who may come in contact with it. e.g. radioactive, hepatitis risk.
   - sampling performed indicator: indicator showing whether the sample has been collected at the time the service order is communicated to the laboratory. e.g. yes, no.

2. Sample to be collected

   Sample to be collected specifies the characteristics applicable for only to samples for which the laboratory service provider has to organize the sample collection. Sample to be collected has following attributes:

   - sampling priority: priority, given by the requester, which the sample collector should attach to the task of collection of the sample. e.g. high, medium, low.

- interval from first sample time: time between a first collection and a current collection.
- request period: requested time during which sample collection should take place. e.g. 24 hours urine collection.

As a part of the integrated schema, figure 4.3 mainly appears on page 5 of Appendix A.

4.4 Healthcare Party

Healthcare party is generalization of any type of healthcare party. As such, it contains the common information to any type of healthcare party.

In Figure 4.4 a healthcare party is always either a healthcare professional or a healthcare organization.

Healthcare party may specialize into a laboratory service requester, a laboratory service provider, a copy destination, a intended recipient of report copy, an origin of medical information, a supervising healthcare party, a sample collector, and a related laboratory service provider.

Healthcare professional represents an individual health care professional, it may optionally be a member of zero or many healthcare organizations.

Healthcare organization may be part of zero or many other healthcare organizations. It may be associated with zero or many instance of healthcare administrative information.

As a part of the integrated schema, figure 4.4 mainly appears on page 2 of Appendix A.

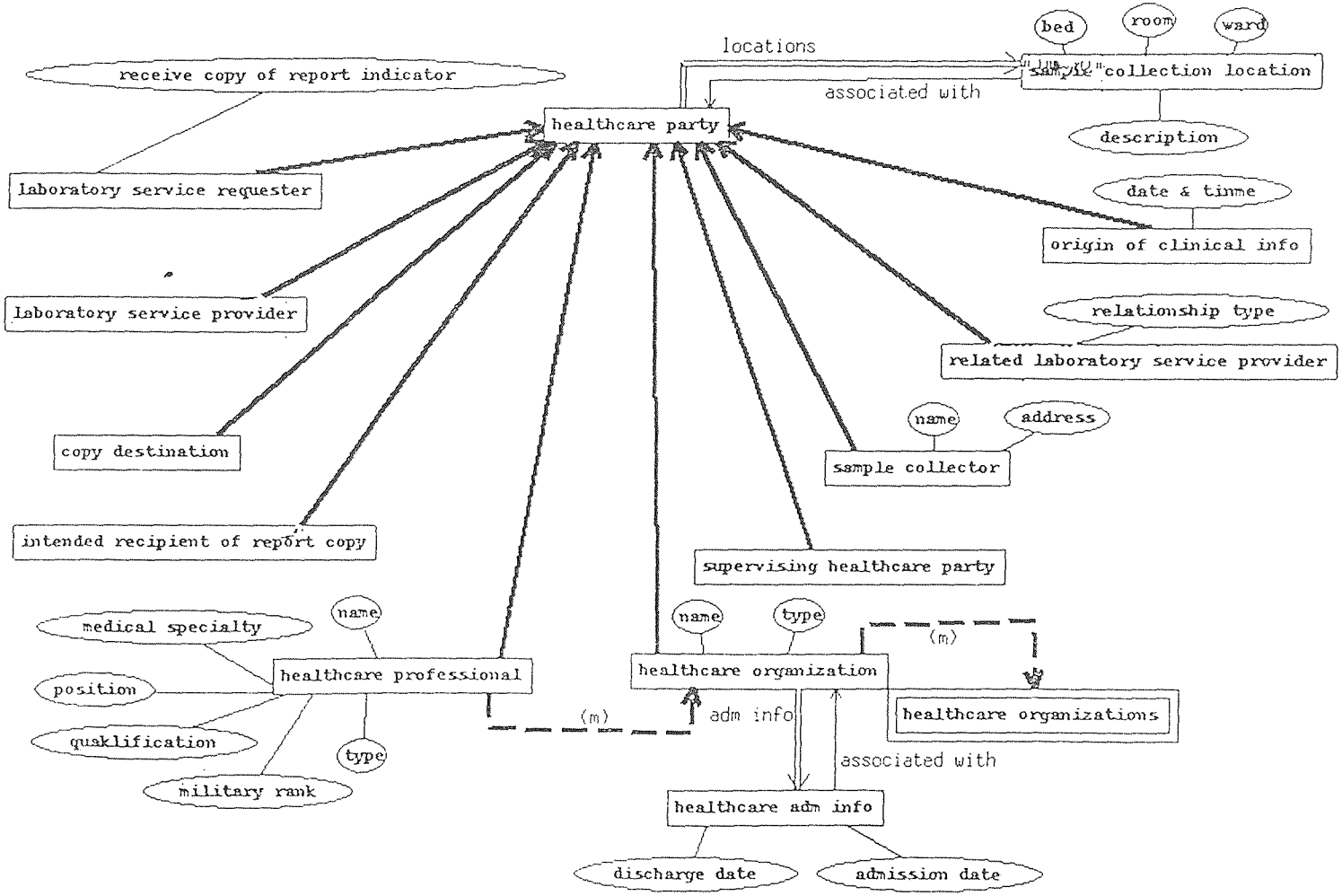

Figure 4.4 Healthcare party

4.5 Integrated Schema

In Appendix A we provide the integrated graphical representation of European Prestandard in three levels. Appendix A.1 shows the graphical schema including all connections between all the classes and also the connections between classes and attributes.

In Appendix A.2 we show the graphical schema obtained in our modeling where attributes are omitted. This is the middle level of display given in OOdini. This level describes the different classes and the generic and user defined relationships connecting them.

In Appendix A.3 we show the third level of display of the schema which describe the classes and only the generic relationships connecting them. The generic relationships appearing in this schema are:

1. subclass which implies inheritance of all the properties of a superclass to a subclass.

2. "part of" which describes the hierarchy of assembling wholes from parts. We see that the "part of" is an important relationship in medical informatics as it has occurences several times in the schema.

3. "member of" which shows the relationship between a class representing an object and a class representing a set of elements of this object.

CHAPTER 5

CONCLUSION

In this paper we have presented a graphical representation, using the OOdini system and language, of the European Prestandard for Medical Informatics for Message Exchange of Laboratory Information. The European Prestandard describes a standardized format for messages to be exchanged between a health care provider and a medical laboratory. Our graphical representation shows the connections between all the classes and also the connections between classes and attributes. We have also introduced OOdini, a constraint-based graphical editor chosen to create and manipulate our graphical representation. This graphical editor gives us the power and flexibility to manipulate the class information at will.

In summary, We have created an integrated graphical representation for better learning, communication, and manipulation of the medical information exchange prestandard.

APPENDIX A

AN INTEGRATED GRAPHICAL REPRESENTATION

A.1 Graphical Representation in Level One

The integrated graphical representation in level one consists of 9 pages, the following map shows the position of each page in this graphical schema.

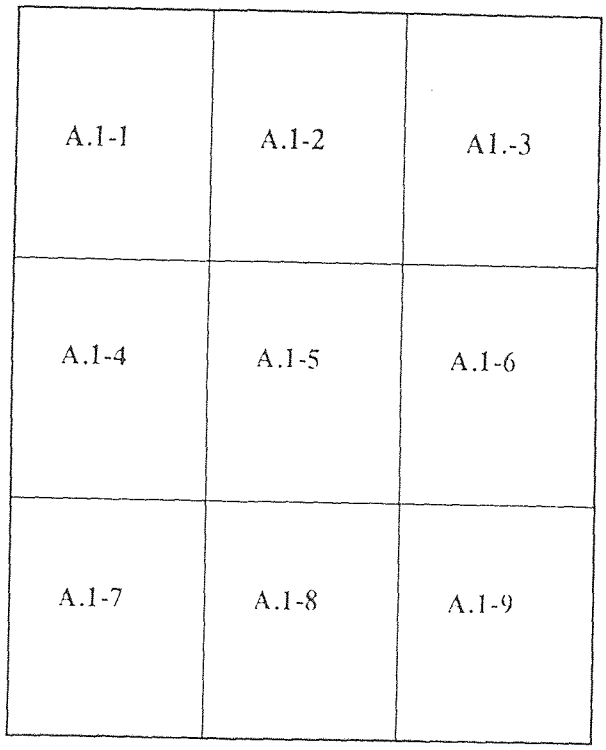

Figure A.1 Map of graphical representation in level one

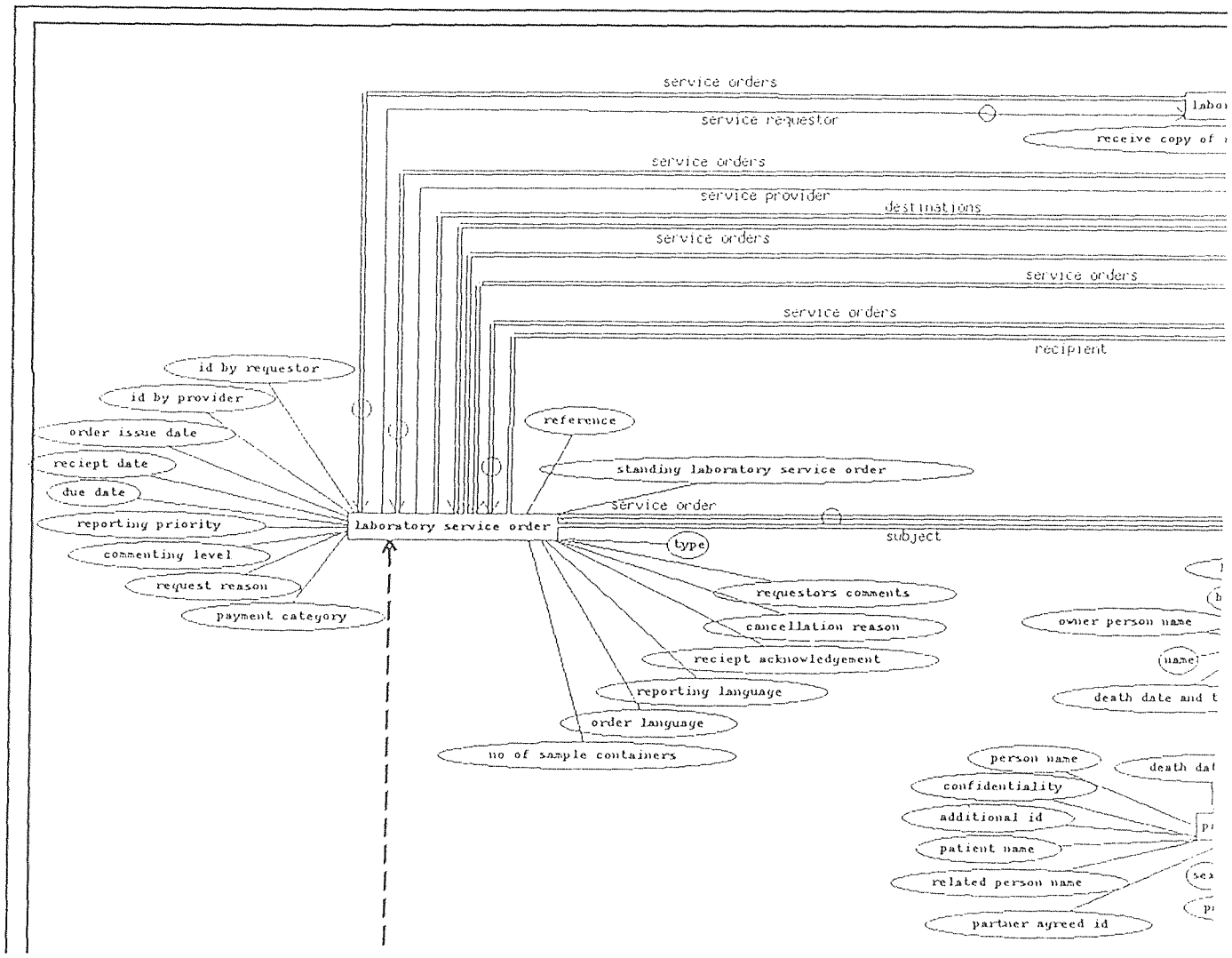

Figure A.1-1 Graphical representation in level one

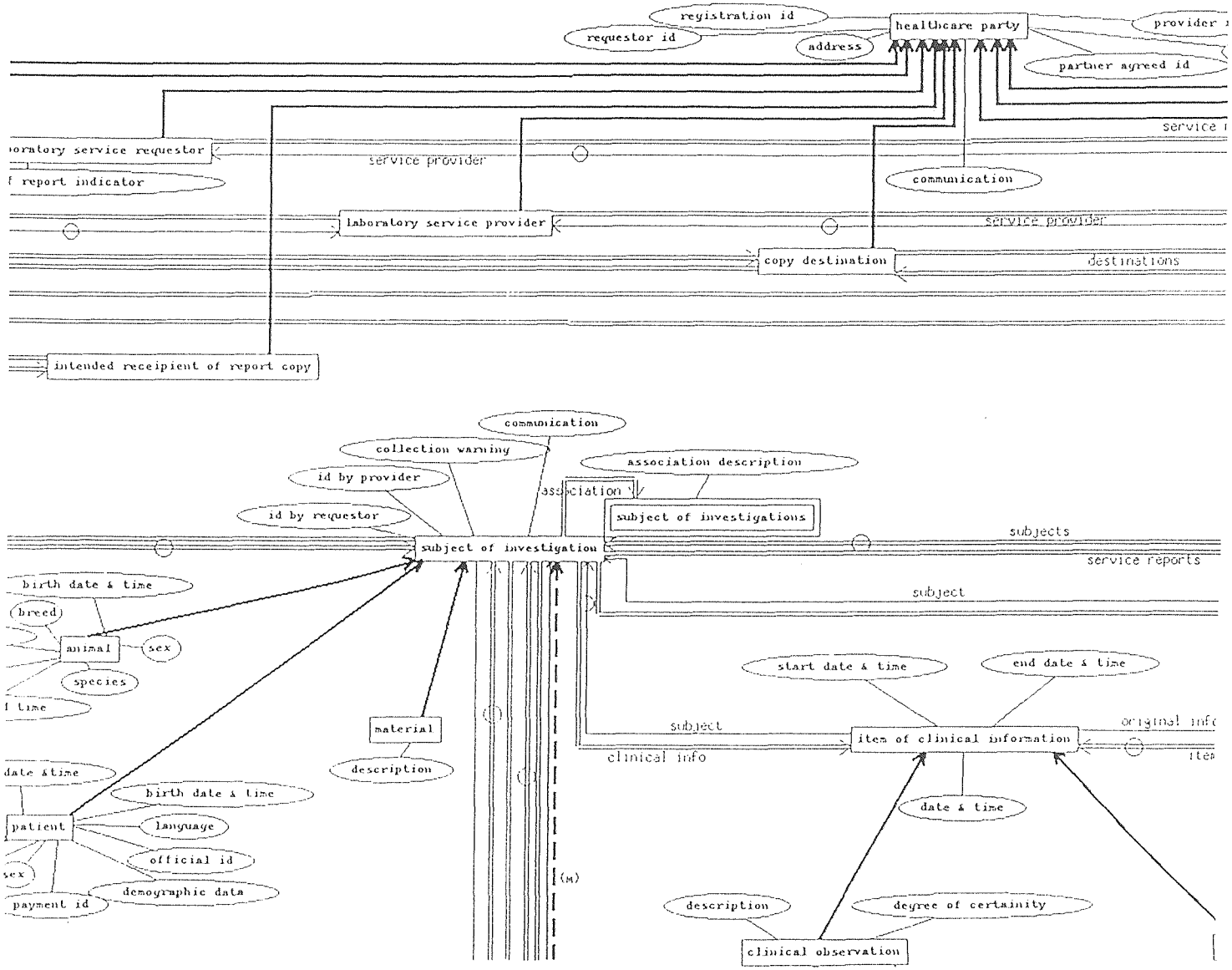

Figure A.1-2 Graphical representation in level one

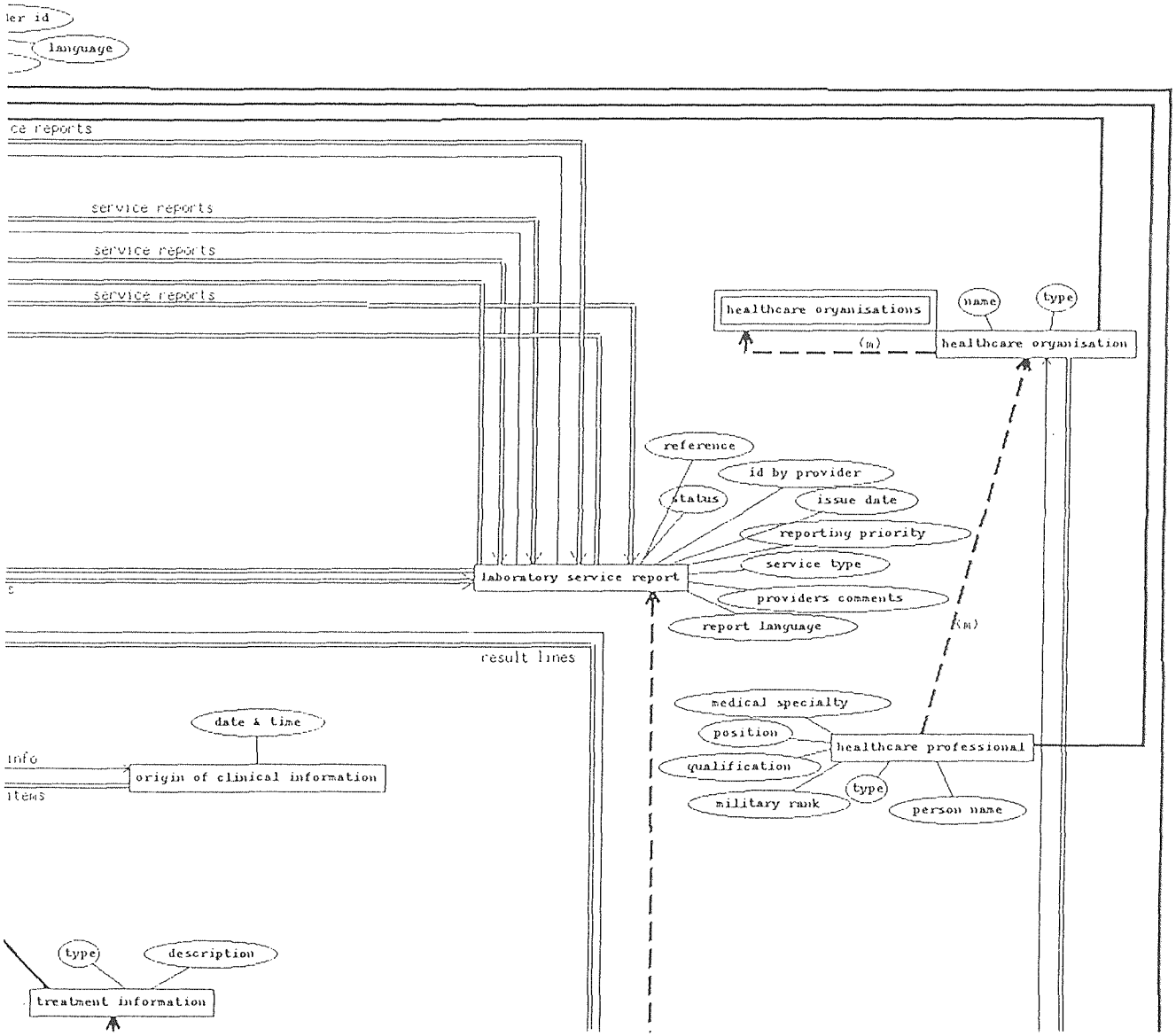

Figure A.1-3 Graphical representation in level one

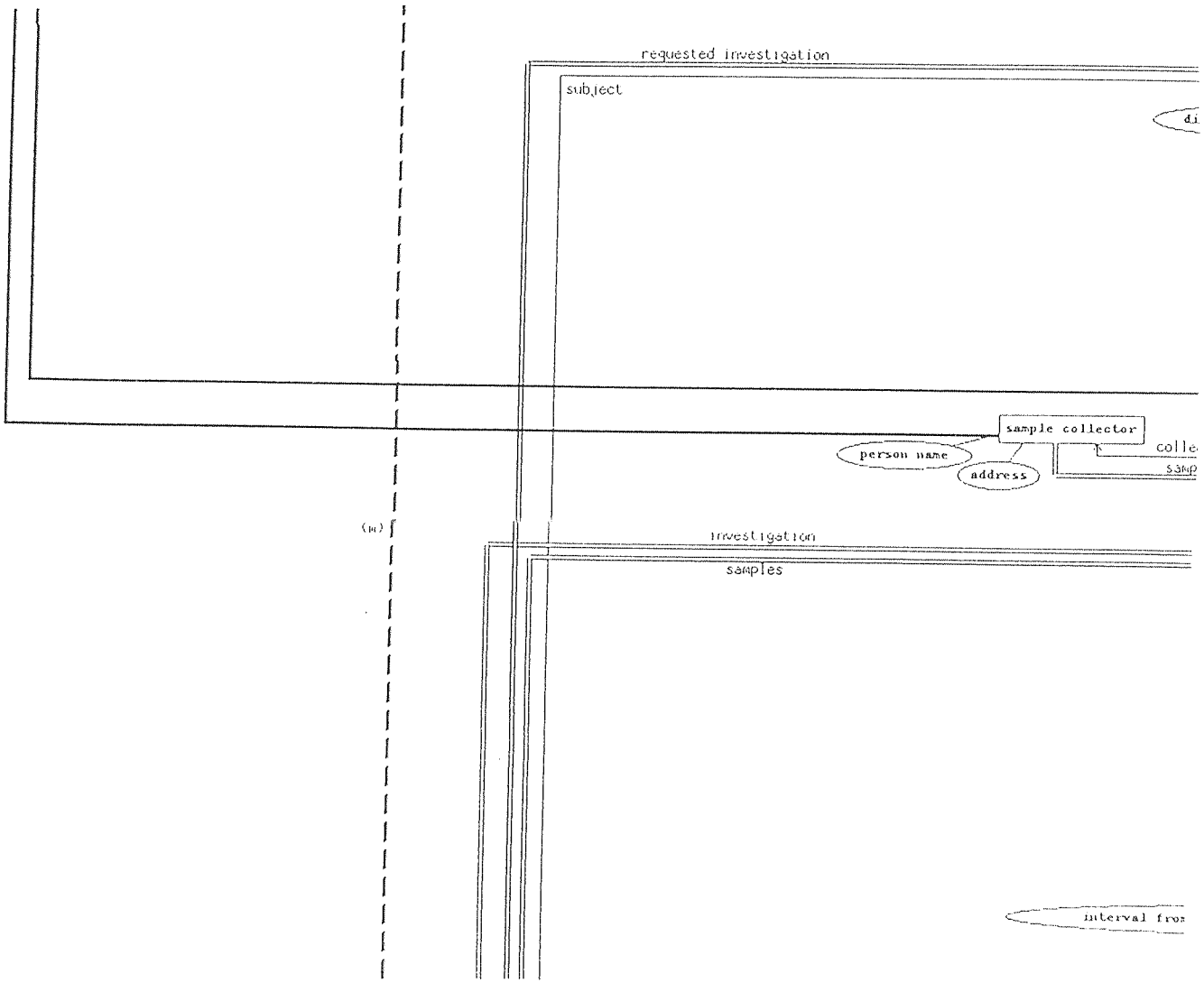

Figure A.1-4 Graphical representation in level one

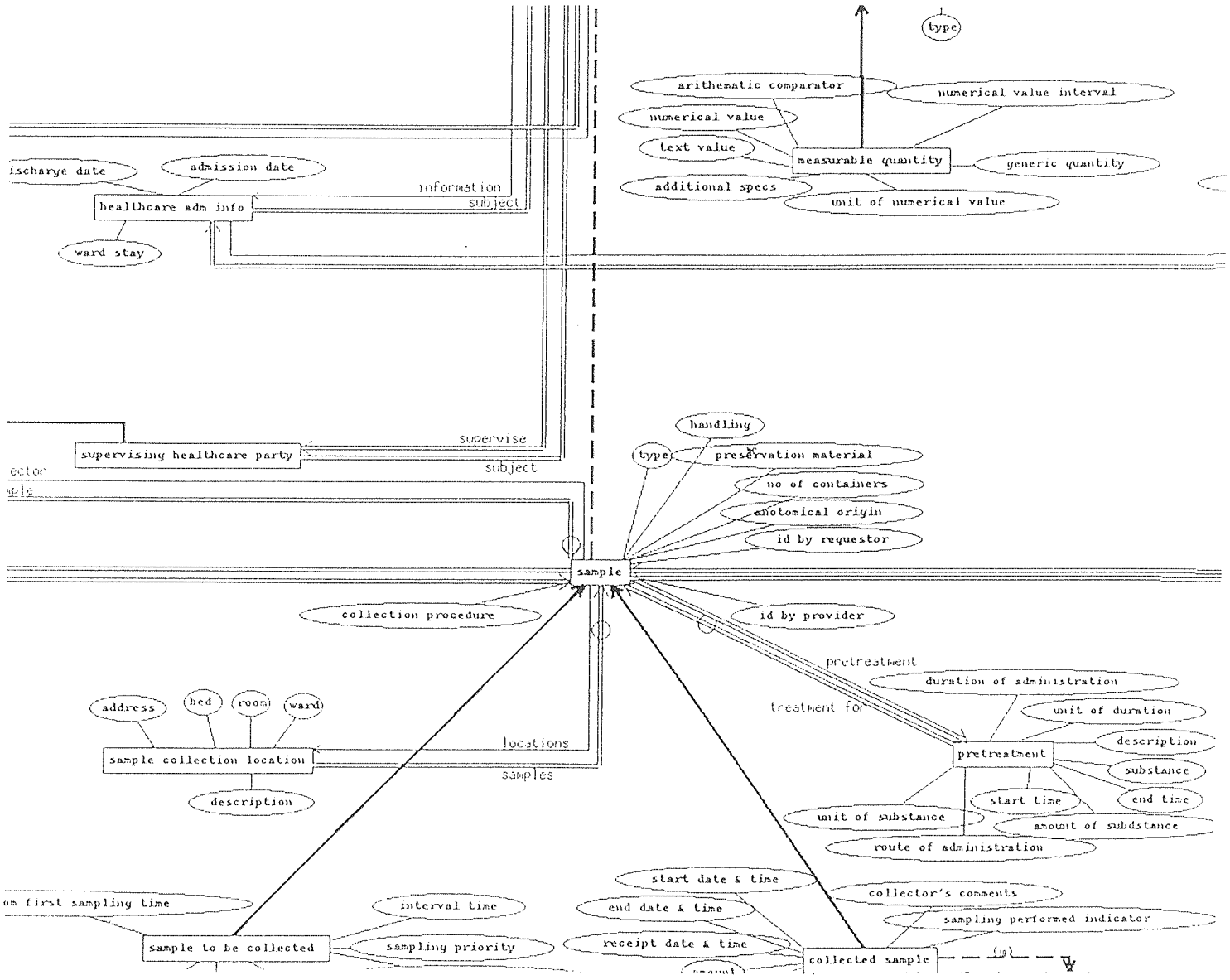

Figure A.1-5 Graphical representation in level one

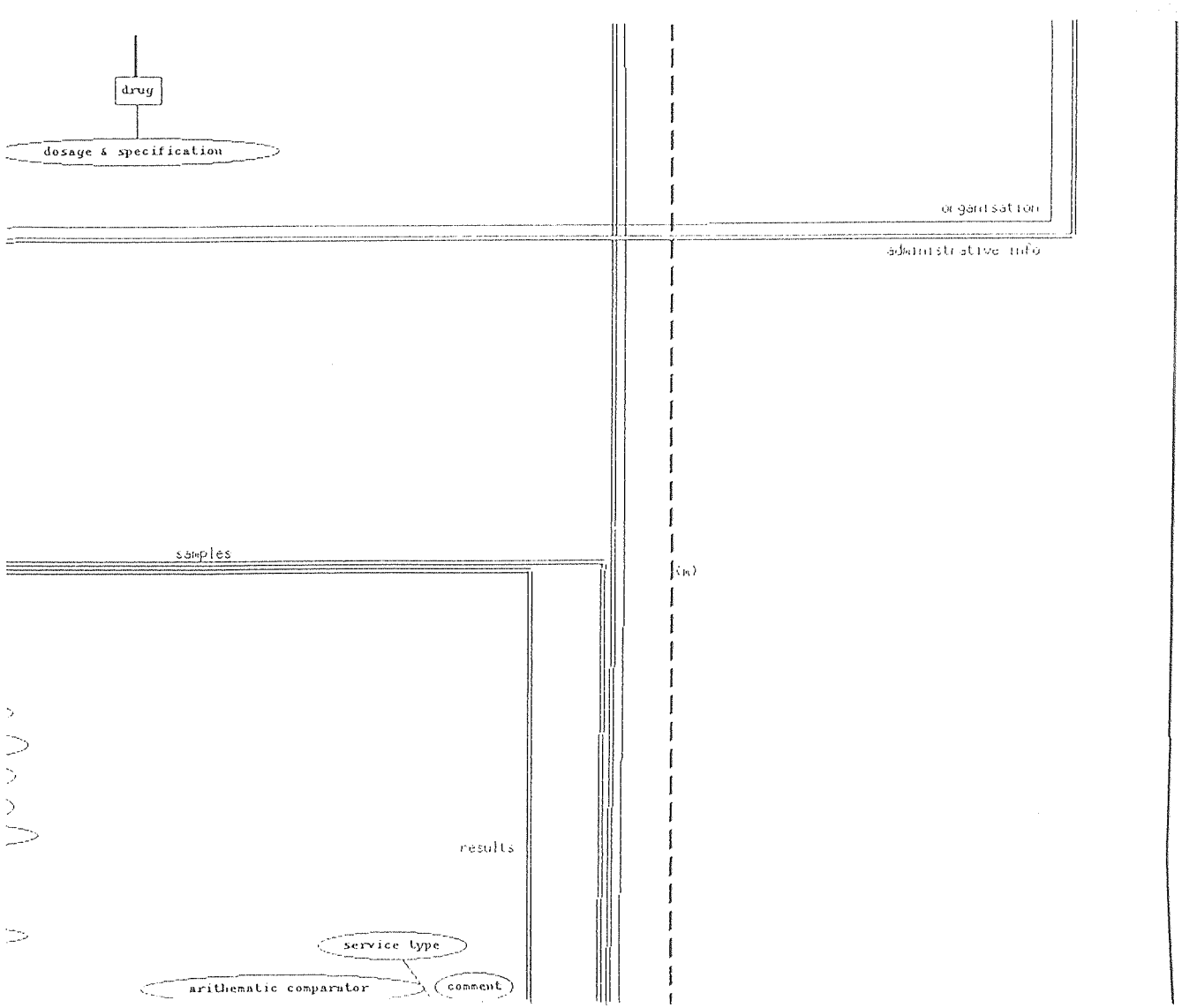

Figure A.1-6 Graphical representation in level one

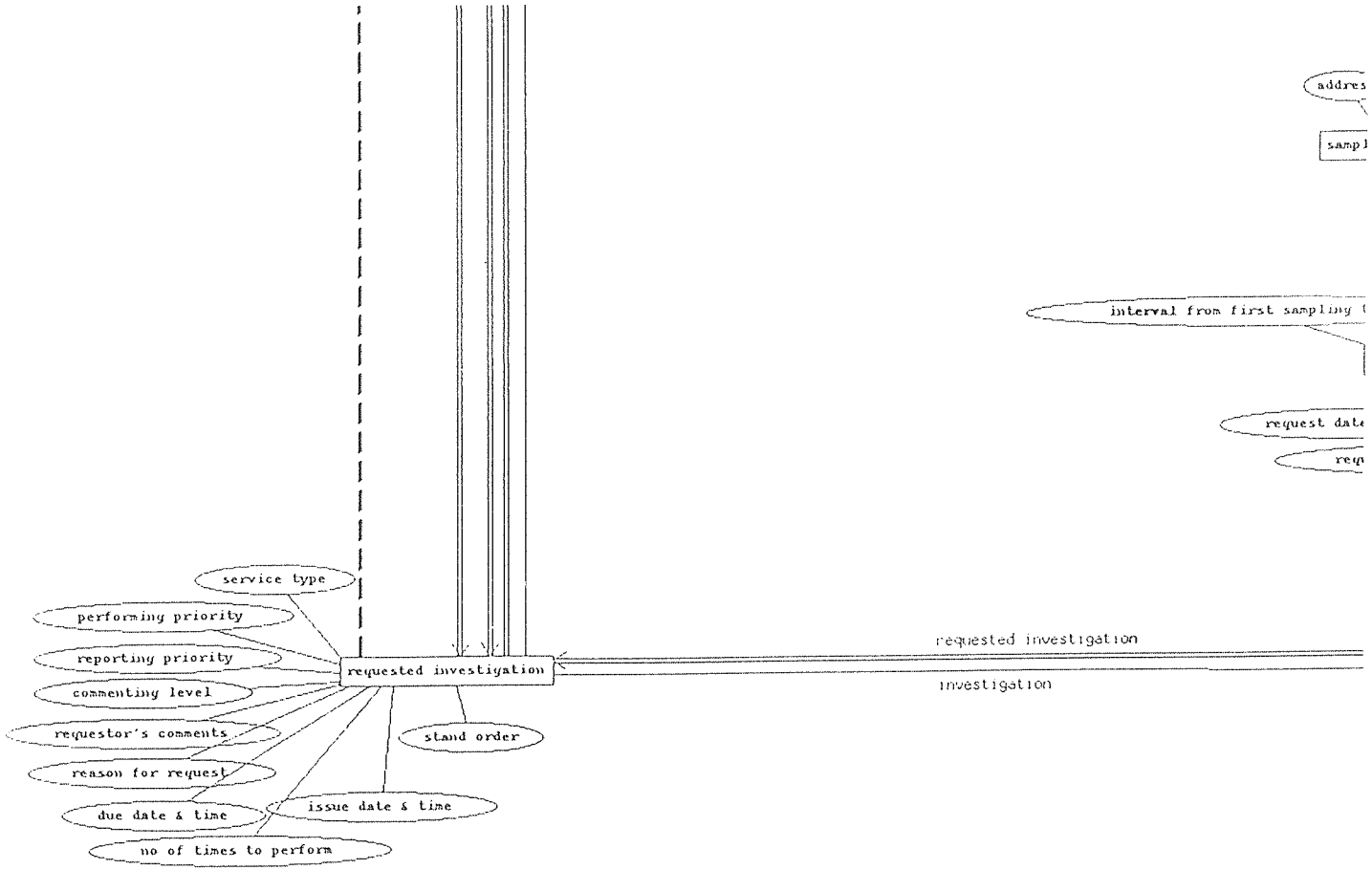

Figure A.1-7 Graphical representation in level one

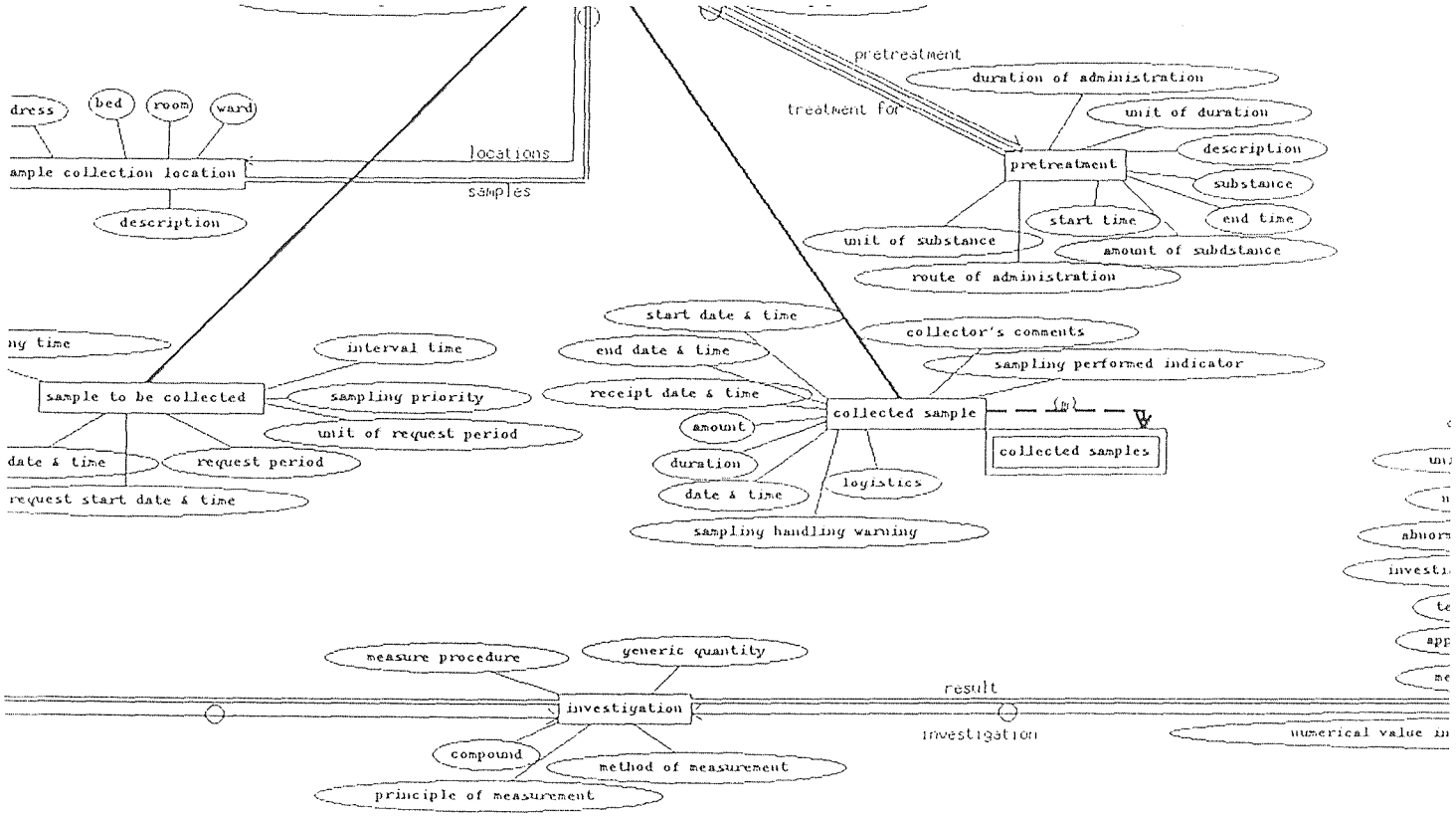

Figure A.1-8 Graphical representation in level one

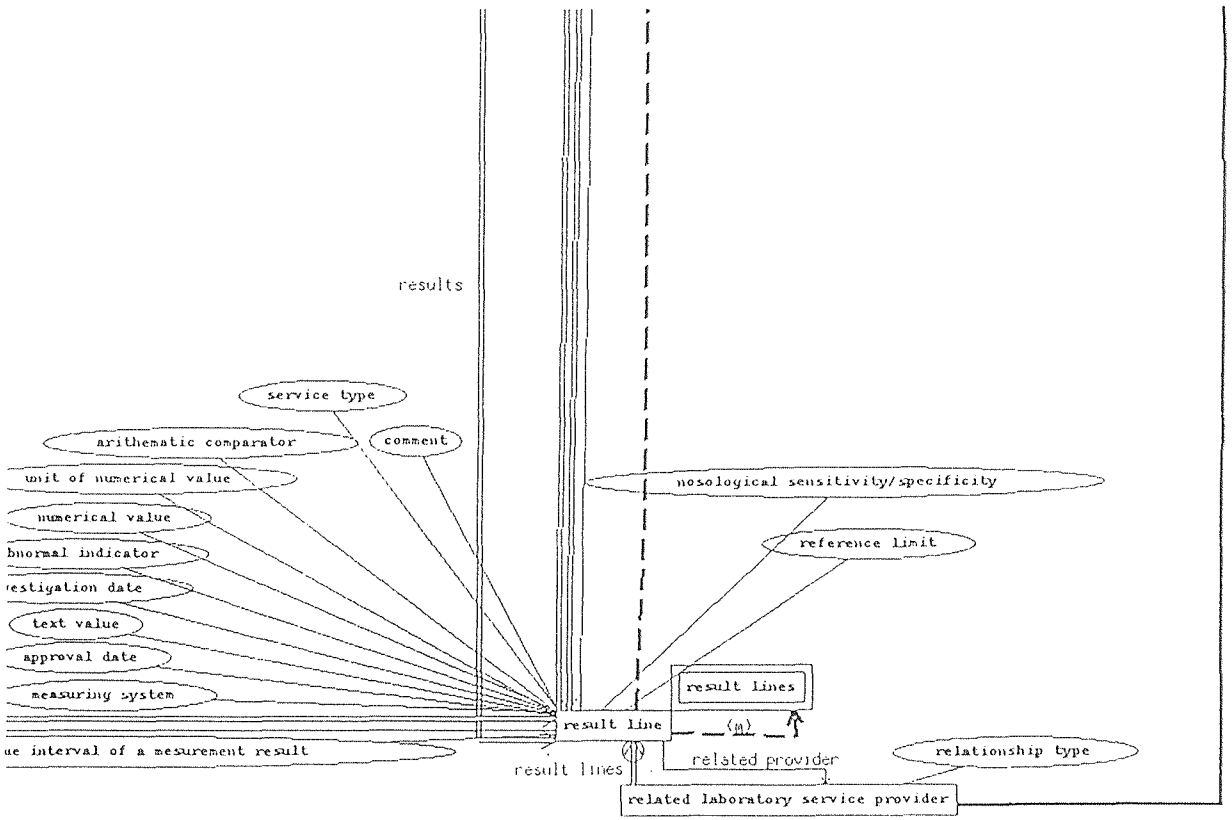

Figure A.1-9 Graphical representation in level one

A.2 Graphical Representation in Level Two

The integrated graphical representation in level two consists of 3 pages, the following map shows the position of each page in this graphical schema.

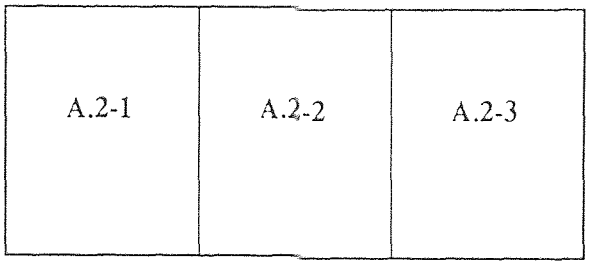

Figure A.2 Map of graphical representation in level two

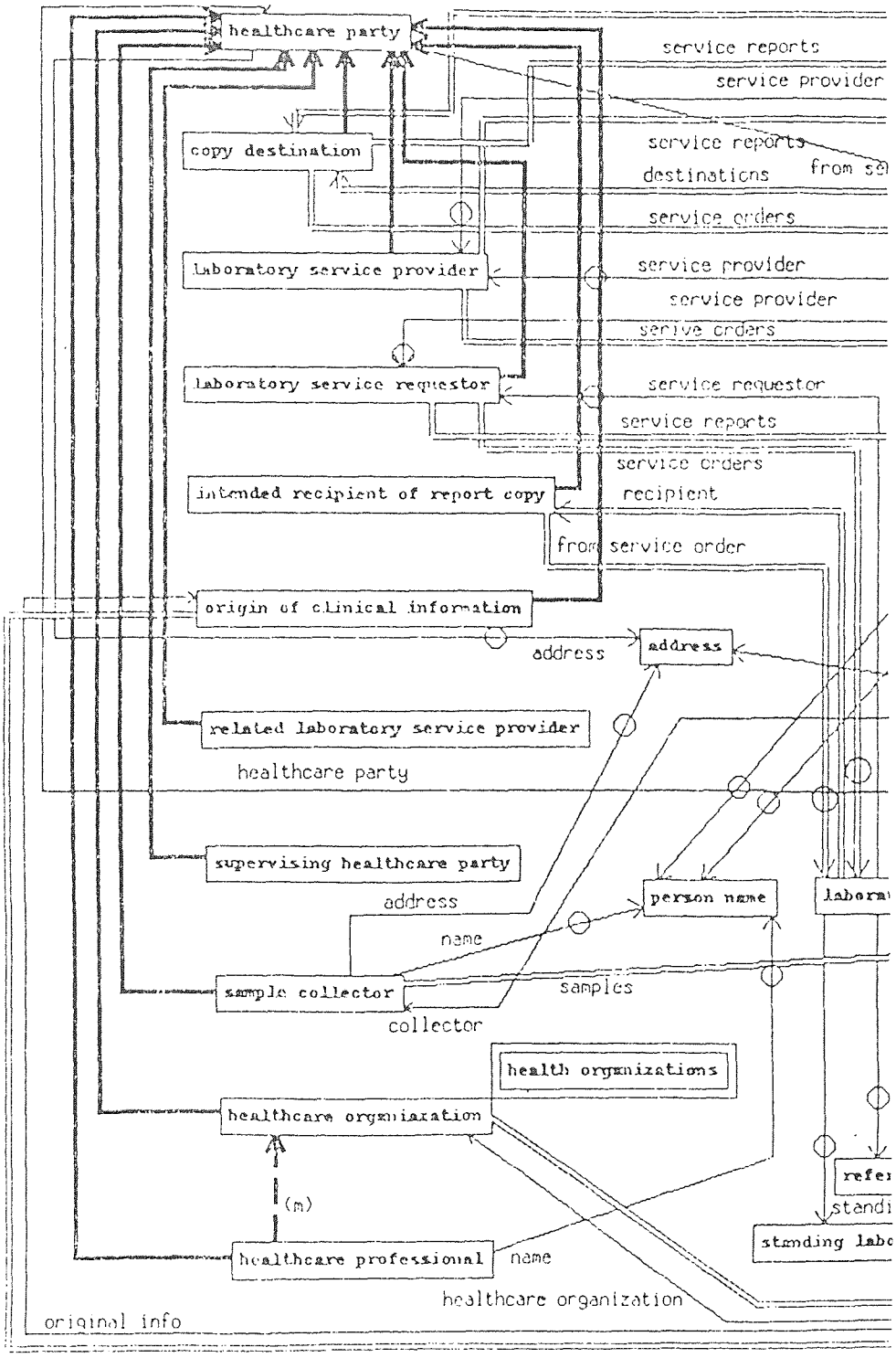

Figure A.2-1 Graphical representation in level two

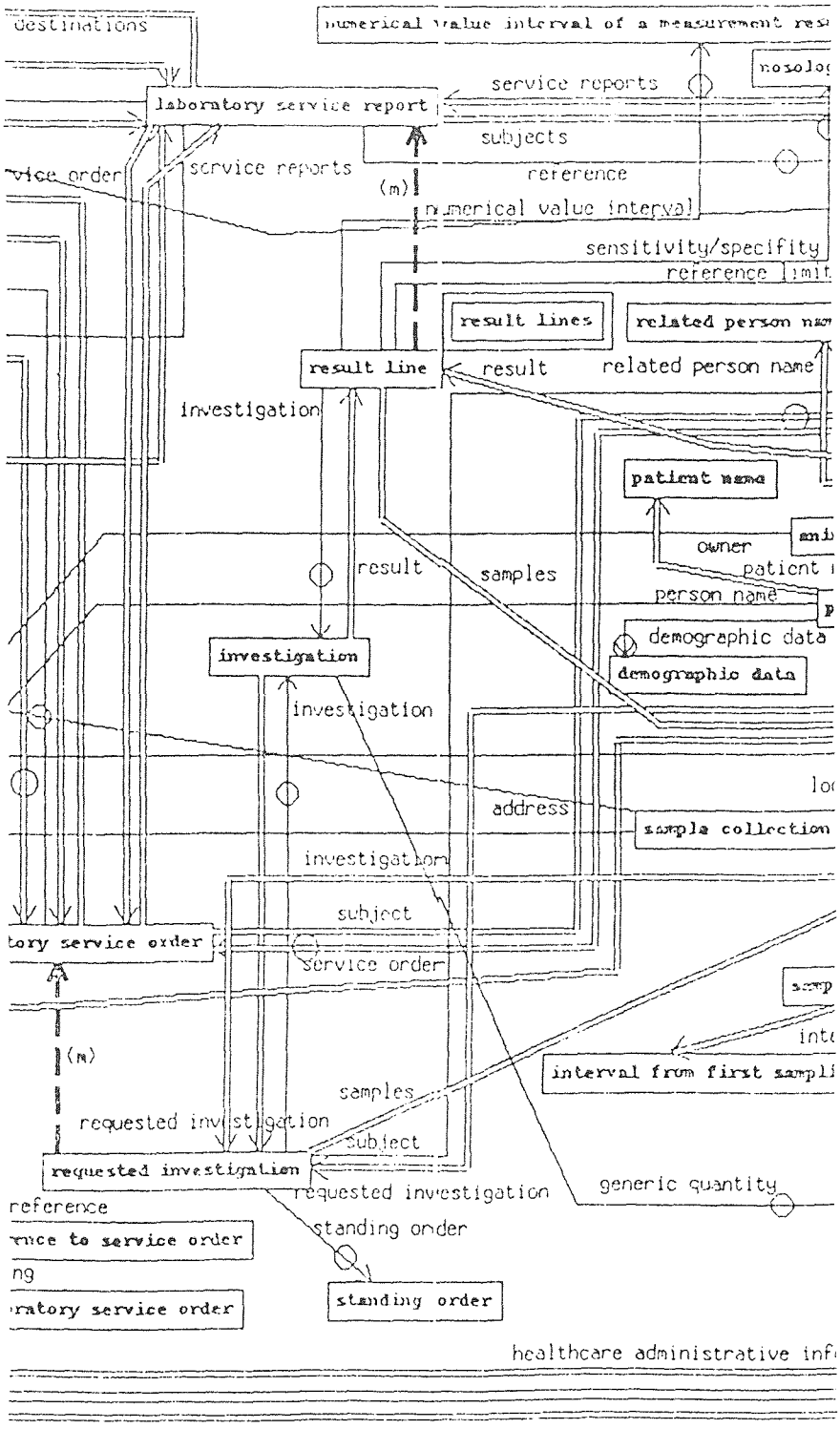

Figure A.2-2 Graphical representation in level two

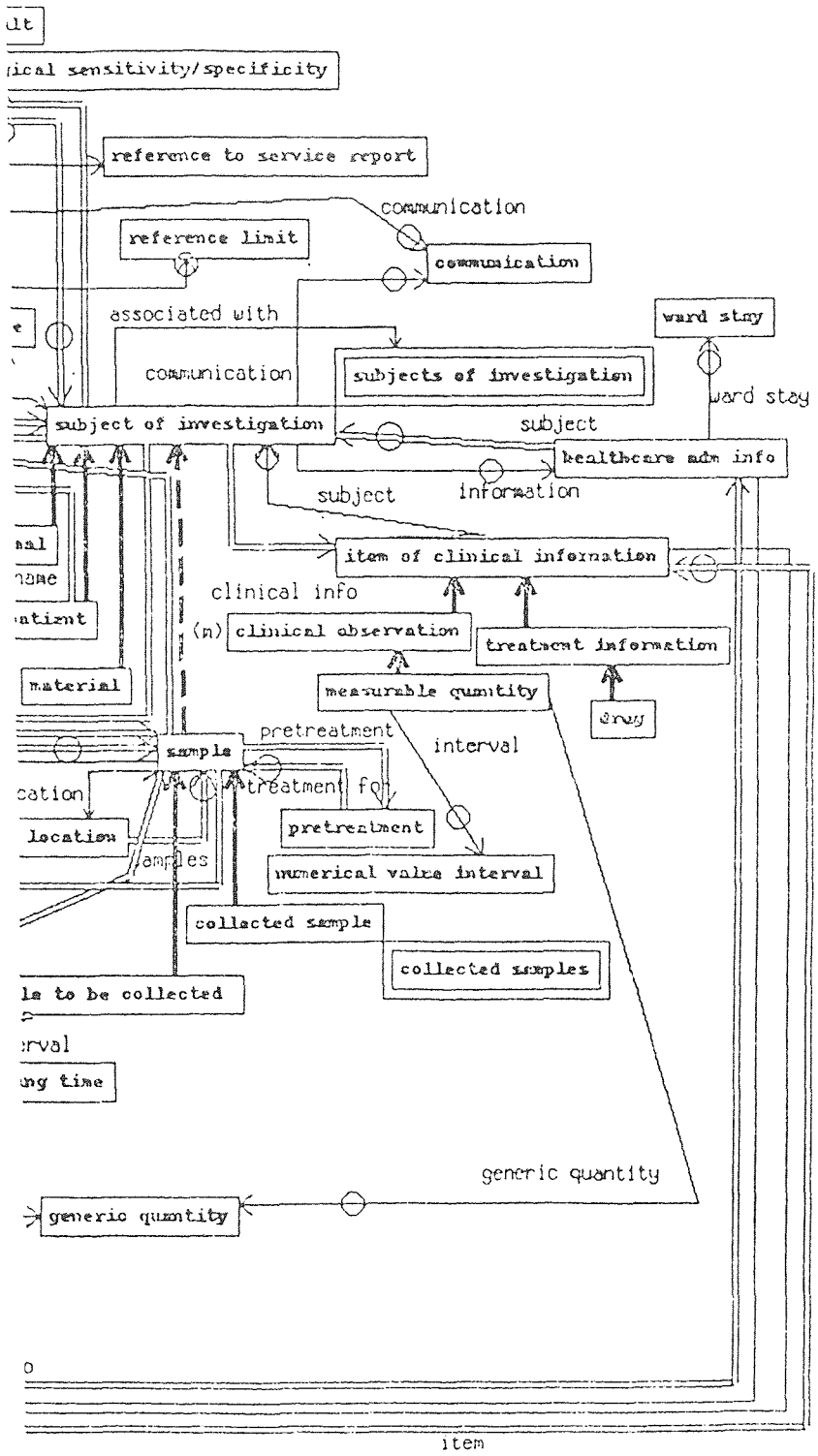

Figure A.2-3 Graphical representation in level two

A.3 Graphical Representation in Level Three

The integrated graphical representation in level three consists of 3 pages, the following map shows the position of each page in this graphical schema.

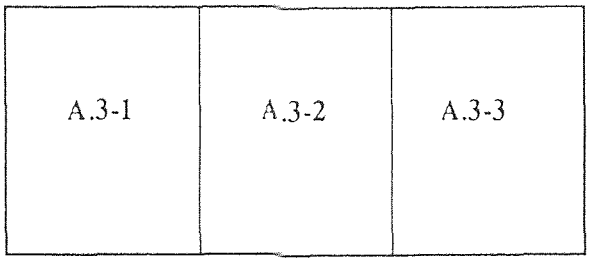

Figure A.3 Map of graphical representation in level three

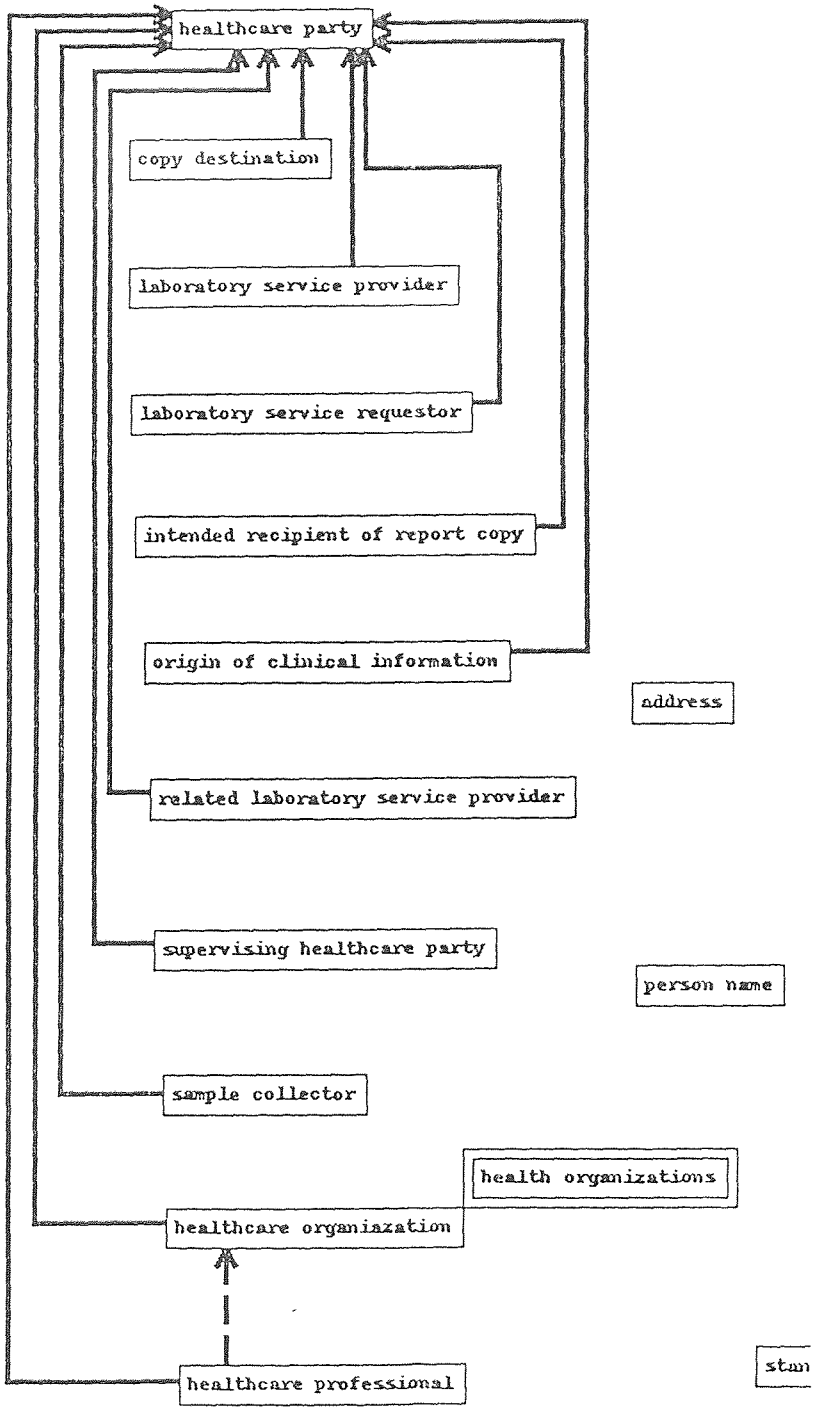

Figure A.3-1 Graphical representation in level three

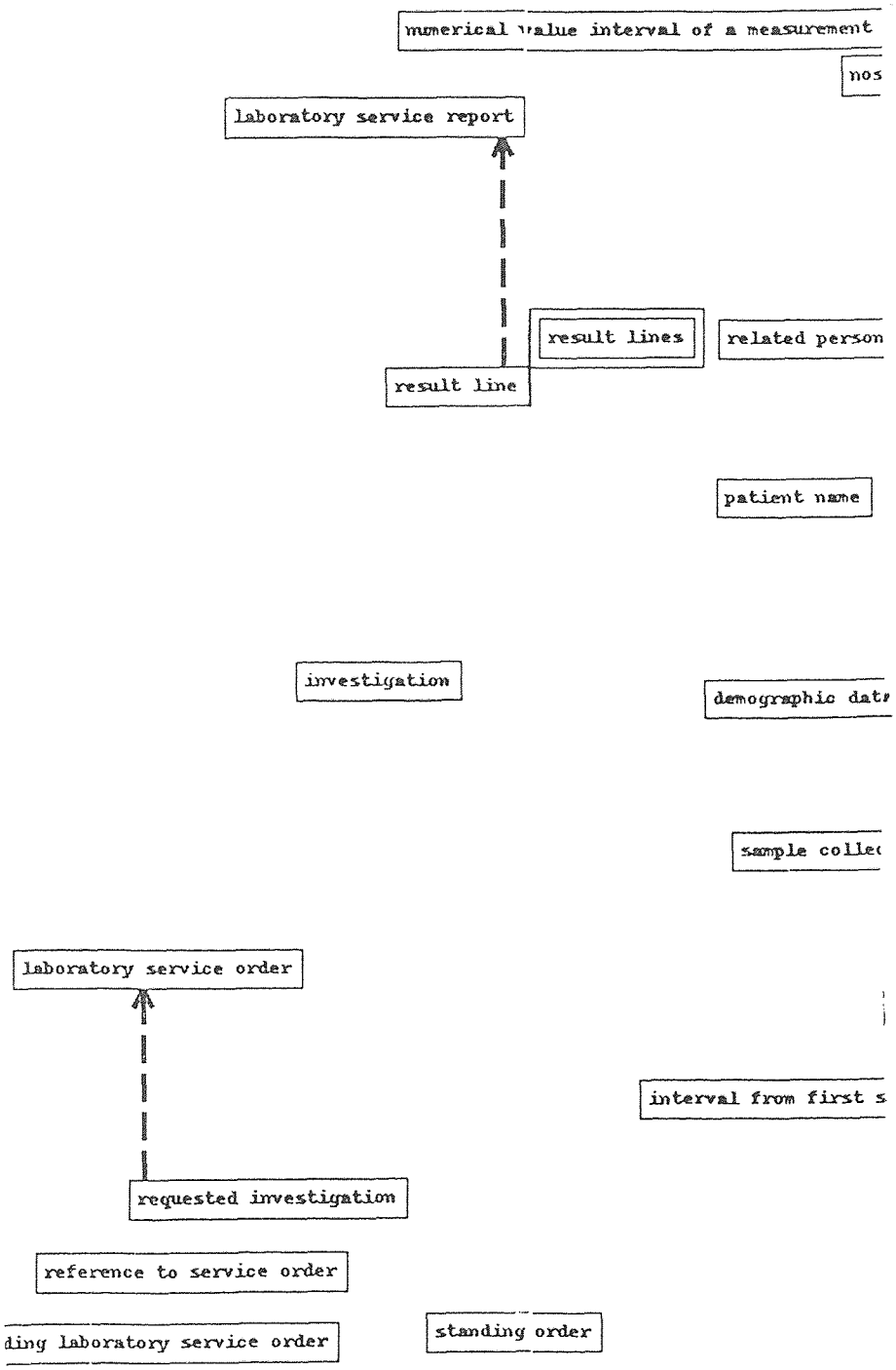

Figure A.3-2 Graphical representation in level three

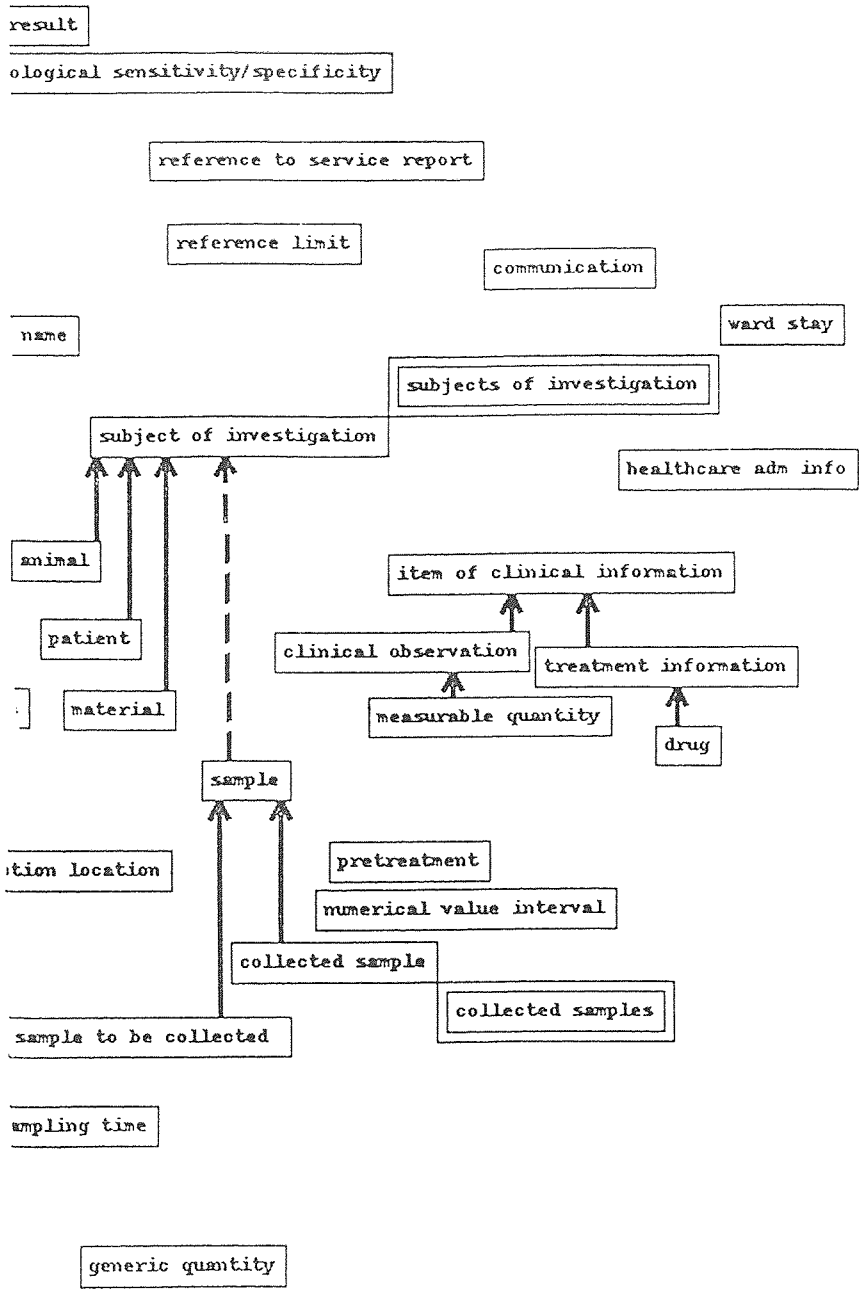

Figure A.3-3 Graphical representation in level three

APPENDIX B

DEFINITIONS

B.1 Object, Attribute and Relationship

- **Animal:**

  Object: the purpose of this object is to allow the specification of the characteristics required when the subject of investigation is an animal.

  Attributes:

  1.animal name:

  2.species: e.g. dog, mouse.

  3.breed: subspecies or special breed of animal.

  4.sex:

  5.birth date: date and time of birth.

  6.death date: date and time of death.

  7.owner name:

  Relationship:

  1.with subject of investigation: an animal is a specialization of a subject of investigation .

- **Clinical Observation:**

  Object: item of clinical information excluding information about performed or intended treatment of the patient.

  Attributes:

  1.type: e.g. diagnosis, symptom, physical sign. .

2.description: e.g. gastric carcinoma, abdominal pain, airline pilot.

3.degree of certainty: degree of certainty that the observation is correct.

Relationships:

1.with item of clinical information: a clinical observation is a specialization of item of clinical information.

2.with measurable quantity: a clinical observation may specialize into a measurable quantity.

- **Collected Sample:**

Object: one or more parts taken from a system and intended to provide information on that system or on a subsystem or to provide a basis for a decision on either of these.

Attributes:

1.date and time: e.g. 10:00pm 26 January 1993, 199301262200.

2.duration: e.g. 1 (second), 8 (hours).

3.transport logistics: means by which a sample reaches the laboratory.

4.receipt date and time: date and time of receipt by the laboratory of a collected sample.

5.sampling handling warning: warning of dangers that the sample presents to those who may come into contact with it..

6.sampling performed indicator: indicator showing whether the sample has been collected at the time the service order is communicated to the laboratory. e.g. Yes, no.

Relationships:

1.with collected sample: a collected sample may be part of zero or one other collected sample; a collected sample may contain zero or many other collected samples.

2.with sample: a collected sample is a specialization of a sample.

- Copy Destination:

Object: party, other than the (laboratory) service provider or (laboratory) service requester, to which a copy of a (laboratory) service report or request is sent.

Relationships:

1.with laboratory service order: a copy destination may be the copy destination for zero or many laboratory service orders.

2.with laboratory service report: a copy destination may be the copy destination for zero or many laboratory service reports.

3.with healthcare party: a copy destination is a specialization of a healthcare party.

- Drug:

Object: this object carries the information that is required to express drug treatments.

Attribute:

1.dosage and specification: information which, together with the drug description, provides a full specification of the subject's treatment with the drug.

Relationship:

1.with treatment information: a drug (treatment) is a specialization of treatment information.

- **Healthcare Administrative Information:**

  Object: information about a patient that is requested by a healthcare organization to enable, finance or manage the provision of healthcare service to that patient or to a related individual.

  Attributes:

  1.admission date: date and time that responsibility for the subjects care passed to /is to pass to a secondary healthcare organization. e.g. date and time the subject is admitted to a hospital as an inpatient.

  2.discharge date: date and time the subject is discharged from inpatient care at a secondary care institution and responsibility for care passes to a primary healthcare provider. e.g. date and time the subject is discharged from inpatient care at a hospital.

  3.administrative status: status of a subject of investigation in relation to specific administrative procedures.

  4.ward stay:

  Relationships:

  1.with subject of investigation: healthcare administrative information may specify one or many subject of investigation.

  2.with healthcare organization: healthcare administrative information may optionally be associated with a single healthcare organization.

- **Healthcare Organization:**

  Object: an organization responsible for the direct or indirect provision of healthcare services to a person or animal, or involved in the provision of healthcare related services such as environmental testing. *Attributes:*

  1.type: e.g. university hospital, private laboratory.

2.name: name of healthcare organization.

Relationships:

1.with healthcare party: a healthcare organization is a specialization of a healthcare party.

2.with healthcare professional: a healthcare organization may consist of zero or many instances of healthcare professionals.

3.with healthcare administrative information: a healthcare organization may consist of zero or many other healthcare organizations.

- **Healthcare Party:**

Object: an organization or a person responsible for the direct or indirect provision of healthcare to an individual or involved in the provision of healthcare-related services such as environmental testing.

Attributes:

1.partner agreed id: identification of a healthcare party agreed upon between communication partners.

2.registration id: unique and official identification of a healthcare party, in general issued by an authorized organization such as a governmental or international body.

3.id by requester: identification of a healthcare party given by a (laboratory) service requester.

4.id by provider: identification of a healthcare party given by a (laboratory) service provider.

5.address:

6.communication:

7.language:

Relationships:

1.specialization: a healthcare party is always either a healthcare professional or a healthcare organization.

2.specialization: a healthcare party may specialize into a laboratory service requester, a laboratory service reporter, a copy destination, an intended recipient of report copy, a supervising health care party, a sample collector, a related laboratory service provider.

3.with sample collection location: a healthcare party may be associated with zero or many sample collection locations.

- **Healthcare Professional:**

Object: a person who is entrusted with the direct or indirect provision of defined healthcare services to a patient or population of patients.

Attributes:

1.type: type of healthcare professional.

2.medical specialty: particular subject area or branch of medical science, as practised by a healthcare professional.

3.position: position of a healthcare professional.

4.qualification: qualification of a healthcare professional.

5.military rank: military rank of a healthcare professional.

6.person name:

Relationships:

1.with healthcare party: a healthcare professional is a specialization of a healthcare party.

2.with healthcare organization: a healthcare professional may optionally be a member of zero or many healthcare organizations.

- **Intended Recipient of Report Copy:**

  Object: a healthcare party to which a copy of a laboratory report is requested to be sent for information.

  Relationships:

  1.with laboratory service order: an intended recipient of a report copy may be mentioned by one or more laboratory service orders.

  2.with healthcare party: an intended recipient of report copy is a specialization of a healthcare party.

- **Investigation:**

  Object: clinical laboratory examination that leads to the production of one or more results.

  Attributes:

  1.compound: chemical compound.

  2.principle of measurement: scientific basis of a measurement.

  3.method of measurement: logical sequence of operations, described generically, used in the performance of measurements.

  4.measurement procedure: set of operations, described specifically , used in the performance of particular measurements according to a given method of measurement.

  5.generic quantity:

  Relationships:

1.with requested investigation: an investigation may be requested through zero or many requested investigations.

2.with result line: an investigation may be reported upon through zero or many result line.

- **Item of Clinical Information:**

Object: component of a set of data describing information clinically relevant to a patient.

Attributes:

1.date and time: date and (if appropriate) time of the occurence of a clinically relevant event.

2.start date and time: the beginning of a period of applicability of an item of clinical information.

3.end date and time: the end of a period of applicability of an item of clinical information.

Relationships:

1.with subject of investigation: item of clinical information is related to exactly one subject of investigation.

2.with origin of clinical information: item of clinical information may optionally be associated with a single origin of clinical information.

3.specialization: item of clinical information is always specialized into either a clinical observation or treatment information.

- **(Laboratory) Service Order:**

Object: set of one or more of requested investigations submitted to a (laboratory) service provider, pertaining to one or more specified system,

usually in one individual, and including pertinent specific and general information.

Attributes:

1.id by requester: code-value assigned by a (laboratory) service requester to a (laboratory) service order for its identification.

2.id by provider: code-value assigned by a (laboratory) service provider to a (laboratory) service order for its identification within the laboratory.

3.order issue date: date and time at which a (laboratory) service order is completed within the requesting system.

4.due date of report: due date and time of laboratory service report. receipt date: date and time at which a (laboratory) service order is received by a laboratory.

5.service type: service type of (laboratory) service order.

6.reporting priority: priority of the reporting of the investigations results, indicated by a requester. 7.commenting level: level of detail that the requester wishes to receive in the laboratory service providers comments upon the (laboratory) service report.

8.request reason: clinical information indicating the rational for ordering given investigation(s).

9.receipt acknowledgement: indication of whether or not the issuer of a message requests acknowledgement of the message receipt by the recipient.

10.payment category:

11.no of sample containers: total number of sample containers related to a laboratory service order. laboratory service order.

12.order language: language of laboratory service order.

13.reporting language: reporting language requested.

14.standing (laboratory) service order: instruction for a (laboratory) service order to be repeated on specified date(s) and time(s) or interval(s).

Relationships:

1.with laboratory services requester: a laboratory service order is requested by a single laboratory service requester.

2.with laboratory service provider: a laboratory service order is ordered to a single laboratory services provider.

3.with copy destination: a laboratory service order may be copied to zero or many copy destinations.

4.with intended recipient of report copy: a laboratory service order may specify zero or many destinations that should receive a copy of the corresponding laboratory reports.

5.towards laboratory service report: a laboratory service order may lead to zero or many laboratory service reports.

6.with subject of investigation: a laboratory service order may related to one or many subject of investigations.

7.with requested investigation: a laboratory service order may contain one or many requested investigations.

- **(Laboratory) Service Provider:**

Object: an authorized healthcare party qualified to perform laboratory services and to validate the resulting (laboratory) service report.

Relationships:

1.with laboratory service order: a laboratory service provider may be the laboratory service provider for one or many laboratory service orders.

2.with laboratory service report: a laboratory service provider may have issued zero or many laboratory service reports.

3.with healthcare party: a laboratory service provider is a specialization of a healthcare party.

- **(Laboratory) Service Report:**

  Object: a report of results of (laboratory) investigations of one or more properties pertaining to one or more specified systems, usually in one individual, and including pertinent information extracted from the (laboratory) service order as well as additional comments, suggestions and advice given by the (laboratory) service provider.

  Attributes:

  1.report id by provider: code-value assigned by a (laboratory) service provider to a (laboratory) service report for its identification.

  2.issue date of report: issue date and time of laboratory service report.

  3.report status: partial, supplementary, complete.

  4.reporting priority: indication by the (laboratory) service provider of the report priority.

  5.report service type: e.g. add, replace.

  6.provider's comment: comment from the report that can not be expressed by any other existing attribute.

  7.report language:

  Relationships:

  1.with laboratory service order: a laboratory service report may refer to zero or many laboratory service orders.

2.with laboratory service requester: a laboratory service report is associated with a single laboratory service requester.

3.with laboratory service provider: a laboratory service report is taken responsibility of by a single laboratory service provider.

4.with copy destination: a laboratory service report may be copied to zero or many copy destinations.

5.with subject of investigation: a laboratory service report may report on one or many subjects of investigation.

6.with result line: a laboratory service report consists of one or many result lines.

- **(Laboratory) Service Requester:**

  Object: an authorized healthcare party issuing a (laboratory) service order for one or more (laboratory) investigations pertaining to one or more systems usually in one individual.

  Relationships:

  1.with laboratory service order: a laboratory service requester may be the requester for one or many laboratory service orders.

  2.with laboratory service report: a laboratory service requester may be the requester associated with zero or many laboratory service reports.

  3.with healthcare party: a laboratory service requester is a specialization of a healthcare party.

- **Material:**

  Object: an inanimate system (the properties of which are subject to investigation).

Attribute:

1.description: code or free text describing the kind of material and its immediate context.

Relationship:

1.with subject of investigation: a material is a specialization of a subject of investigation.

- **(Measurable) Quantity:**

  Object: an attribute of a phenomenon, body or substance that may be distinguished qualitatively and determined quantitatively.

  Relationships:

  1.with clinical observation: a measurable quantity is a specialization of a clinical observation.

- **Origin of Clinical Information:**

  Object: a known source of clinical information relevant in the context of a (laboratory) service order or report.

  Relationships:

  1.with item of clinical information: an origin of clinical information is the source of one or many items of clinical information.

  2.with healthcare party: an origin of clinical information is a specialization of a healthcare party.

- **Patient:**

  Object: an individual who has been, is or will be subject to clinical investigation or therapy.

  Attributes:

1.partner agreed id: unique code assigned by an authorized organization to a patient for identifications as agreed upon between the communication partners.

2.offical patient id: identification of a patient assigned by a national healthcare authority.

3.related person name:

4.demographic data:

5.birth date:

6.death date:

7.anguage:

8.confidentiality constraints; information about a patient that is of relevance in determining the type of patient information which may be shared by staff in the receiving healthcare organization and the degree/extent to which it may be shared.

Relationship:

1.with subject of investigation: a patient is a specialization of a subject of investigation.

- **Pretreatment:**

Object: an administration before sampling or measurement, of specified substances that prepare or challenge a system.

Attribute:

1.substance: drug or other chemical compound administered as pretreatment.

Relationship;

1.with sample: a pretreatment is performed in view of the collection of one or many samples.

- **Related (Laboratory) Service Provider:**

  Object: the purpose of this object is the specification of the healthcare parties which are associated with a given result line, but which are not the laboratory service provider of the laboratory service report as a whole. The object is specified in more detail by the healthcare party sub schema.

  Attribute:

  1.substance: drug or other chemical compound administered as pretreatment.

  Relationships:

  1.with result line: a related laboratory service provider is associated with one or many result lines.

  2.with healthcare party: a related laboratory service provider is a specialization of a healthcare party.

- **Requested Investigation:**

  Object: request for a single (laboratory) service to be carried out in respect of a specified subject of investigation.

  Attributes:

  1.service type:

  2.performing priority: priority attached by the requester to the performing of an investigation specified within a (laboratory) service order.

  3.reporting priority: the priority which the requester wishes the (laboratory) service provider to attach to reporting of the result(s) of the requested investigation.

  4.standing order: an instruction for a requested investigation to be repeated on specified date(s) and time(s) or interval(s).

5.due date and time: date and time by which the requester wishes to receive the result(s) of an investigation.

6.issue date and time: date and time at which a requested investigation is registered upon the requesting system.

7.number of times to perform:

Relationships:

1.with laboratory service order: a requested investigation is part of exactly one laboratory service order.

2.with investigation: a result line is the result for exactly one investigation.

3.with related laboratory service provider: a result line is associated with maximum one related laboratory service provider.

4.with result lines: a result line may consist of zero or many other result lines. A result line may be a member of zero or one result lines.

- **Result Line:**

Object: collection of information including all essential or useful data relevent to the result of single investigation.

Attributes:

1.service type:

2.arithmetic comparator:

3.numerical value: e.g. 140 when a result is 140 mol/L.

4.numerical value interval: lower and upper value defining an interval in which the measurement result may be situated. e.g. 0 – 10.

5.unit: chosen reference quantity that may be used for comparison of quantities of the same kind. e.g. mole.

6.status: e.g. unverified, pending, new, modified.

7.deviating result indicator: indicator of degree of deviation from reference values of a measurement result.

8.comment:

9.approval date:

10.investigation performed date:

11.refrence limits:

12.nosological sensitivity/specificity:

13.measuring system: complete set of measuring instruments and other equipment assembled to carry out specified measurements.

Relationships:

1.with laboratory service report: a result line is part of exactly one laboratory service report.

2.with subject of investigation: a result line is a result associated to zero or one subject of investigation.

3.with sample: a result line is a result associated with zero or more samples.

4.with investigation: a result line is the result for exactly one invest igation.

5.with related laboratory service provider: a result line is associated with maximum one related laboratory service provider.

6.with result lines: a result line may consist of zero or many other result lines. A result line may be a member of zero or one result lines.

- Sample:

Object: one or more parts taken or to be taken from a system and intended to provide information on that system or on a subsystem, or to provide a basis for a decision on either of these.

Attributes:

1.requestor sample id: code-value assigned by a (laboratory) service requester to a sample for its identification.

2.provider sample id: code-value assigned by a (laboratory) service provider to a sample for its identification.

3.type: e.g. urine, blood, sputum.

4.anatomical origin: e.g. left knee.

5.handling: action taken after collection of a sample and preparatory to measurement.

6.preservation material: e.g. plain glass, citrated plastic.

7.no of containers: number of containers for a given type of sample.

8.collection procedure: procedure directly associated with collection of a sample from the subject of investigation.

Relationships:

1.with subject of investigation: a sample is a part of a single subject of investigation, but it may also not be an immediate part of the subject of investigation.

2.with requested investigation: on a sample, there may be zero or many requested investigations to be performed.

3.with result line: for a sample, there may be zero or many result lines associated with it.

4.with sample collector: a sample may optionally be associated with maximum one sample collector.

5.with pre-treatment: a sample may be specified by zero or many pre-treatment actions.

6.specialization: a sample is always either a sample to be collected, or a collected sample.

- **Sample Collection Location:**

  Object: a geographic location where sampling is requested to be performed or is performed.

  Attributes:

  1.address:

  2.ward:

  3.room:

  4.bed:

  5.description:

  Relationships:

  1.with sample: a sample collection location is the location where one or many samples are (to be) collected.

  2.with healthcare party: a sample collection may optionally be associated with a single healthcare party.

- **Sample Collector:**

  Object: a person who collects the sample.

  Attributes:

  1.person name:

  2.address:

Relationships:

1.with sample: a sample collector is the healthcare party that collected or is to collect one or many samples.

2.with healthcare party: a sample collector is a specialization of a healthcare party.

- **Sample To Be Collected:**

Object: a sample to be collected directly or indirectly via a (laboratory) service provider.

Attributes:

1.sampling priority: priority, given by the requester, which the sample collector should attach to the task of collection of the sample.

2.request date and time: request date and time of sample collection.

3.request start date and time: request start date and time of sample collection.

4.interval time: time between a first collection and a current collection.

5.diff from start time: difference from start sampling time.

6.request period: requested time during which sample collection should take place.

Relationship:

1.with sample: a sample to be collected is a specialization of a sample.

- **Subject of Investigation:**

Object: patient, animal or material subject to a clinical laboratory investigation.

Attributes:

1.id by requester: code-value assigned by a (laboratory) service requester to a subject (patient, animal, material) for its identification.

2.id by provider: code-value assigned by a (laboratory) service provider to a subject (patient, animal, material)for its identification.

3.collection warning: information given to a collector about the subject of investigation that is relevant to a collection of a sample. e.g. radioactive.

4.association description: the relationship between associated subject of investigation. e.g. brother, spouse, share workplace hazard.

Relationships:

1.with laboratory service order: a subject of investigation may be associated with one or many laboratory service orders.

2.with laboratory service report: a subject of investigation may be reported upon by zero or many laboratory service reports.

3.with requested investigation: a subject of investigation may be the subject to perform zero or many requested investigations upon.

4.with result line: a subject of investigation may be the subject reported upon (immediately) through zero or many result lines.

5.with sample: a subject of investigation is the whole of which zero or many samples are collected.

6.with supervising healthcare party: a subject of investigation may supervised by zero or many supervising healthcare parties.

7.with healthcare administrative information: a subject of investigation may be specified by zero or one instances of healthcare administrative information objects.

8.with item of clinical information: a subject of investigation may be specified by zero or many items of clinical information.

9.with subjects of investigation: a subject of investigation may be associated with zero or many other subjects of investigation.

10.specialization: a subject of investigation is either an animal, a patient, or a material.

- **Supervising Healthcare Party:**

  Object: a healthcare professional, sub-department, department or organization officially in charge of the supervision of the healthcare of a patient.

  Relationships:

  1.with subject of investigation: a supervising healthcare party may supervise one or many subject of investigation.

  2.with healthcare party: a supervising healthcare party is a specialization of a healthcare party.

- **Treatment Information:**

  Object: information about medical or surgical actions performed on or planned to be performed on a subject of investigation for the purpose of preventing or combating disease.

  Attributes:

  1.type:

  2.description:

  Relationships:

  1.with item of clinical information: Treatment Information is a specialization of Item of clinical Information.

2.specialization: a treatment information may specialize into drug (treatment).

REFERENCES

[1] European Committee for Standardization, "Medical Informatics Messages for Exchange of Laboratory Information," Draft 5.0, May 1993.

[2] M. Halper, J. Geller, Y. Perl, and E. Neuhold, "A Graphical Schema Representation for Object-Oriented Databases," First International Workshop on Interfaces to Database System (IDS-92), Glasgow, Scotland, 1992 Springer Verlag, pp282-307.

[3] Peter Wegner. "An Object-Oriented Classification Paradigm," In Schiver and Wegner, editors, Research Directions in Object-Oriented Programming. MIT Press, 1987.

[4] Peter Coad, Edward Yourdon, "Object Oriented Analysis," 2nd edition, 1991, Yourdon Press.