Chapter 5: Modeling a Knowledge Management System on Parkinson's Disease

5.1 Introduction

In chapters 3 and 4, we described the development of the database and the ontological integration of the heterogeneous data sources. In enterprise systems, applications accessing different data sources and developed on cross-platforms need to effectively communicate with each other. Such software systems built on object-oriented languages need to be designed and analysed prior to the development of the system for it to be effective. This can be done by modeling the artifacts of the system that forms the blueprint of the system. Unified Modeling Language (UML) provides the basis for modeling such systems since it enables the modeling that encompasses the wide range of domain applications [63].

Modeling information systems using UML reduces the development costs. This is because modeling invariably involves the reiteration of the analysis and the design stage of the project before embarking on the developmental aspect of the project. In the previous chapter we discussed the integration of heterogeneous data sources by the use of ontology. The knowledge based system in our case is not a stand alone system. We have built a knowledge based architecture which interacts with both the information system and the different parts of the knowledge system. Since there is no standard by which knowledge management systems can be modeled, it is essential to use techniques that have already been standardized in software engineering practice. The availability of extensions in UML Profile allows the modeling of knowledge management systems that can then be used to model the information system.

The use of UML as the paradigm for modeling ontologies in DAML+OIL is being discussed in this chapter. The textual ease of use, unambiguity and absence of any side-

effects [62], makes it an attractive choice for the modeling of ontologies that can map the software engineering artifacts to the ontological primitives of DAML+OIL. This chapter proposes the use of UML Profile to facilitate the representation of a knowledge management system for PD. The development of such a bio-ontology using UML is regarded as an abstraction for the domain of discourse [64].

5.2 Modeling of knowledge engineering of Speech and Language therapy for PD

While a tutorial on UML is beyond the ken of discussion, a brief overview relevant to the topic is briefly discussed. In UML, classes are represented by rectangles while relationships are represented by lines joining the related classes. The ends of an association are called roles and the cardinality of a class is represented at the other end of the class. The open arrow indicates that the association is navigable only in one direction while the closed rhombus denotes a compositional relationship; whereby the class at the other end is not aware of the association. Bi-directional navigation does not show any arrows. The line with the closed arrow denotes a generalisation/specialisation relationship while a dependency is indicated by a broken arrow. The dog-eared rectangle in the diagram indicates notes for reference purposes. Stereotypes are represented as <<>>.

The ontology for the domain of Speech and language therapy (PDSpeechtherapy) has been developed using ArgoUML♦ and includes 3 packages, viz. **Communication**, **TherapyApproaches** and **Swallowing**, as illustrated in Figure 5.1. The package for **SpeechTherapy** corresponds to the DAML+OIL ontology and this is indicated by the stereotype DAMLontology. This package consists of the package **Communication** which 'accesses' the package **TherapyApproaches**, and like it, 'imports' all the elements from the target package of **Swallowing**. The functionality of each of the packages for the domain is described in Table 5.1.

♦ tigris.argouml.org

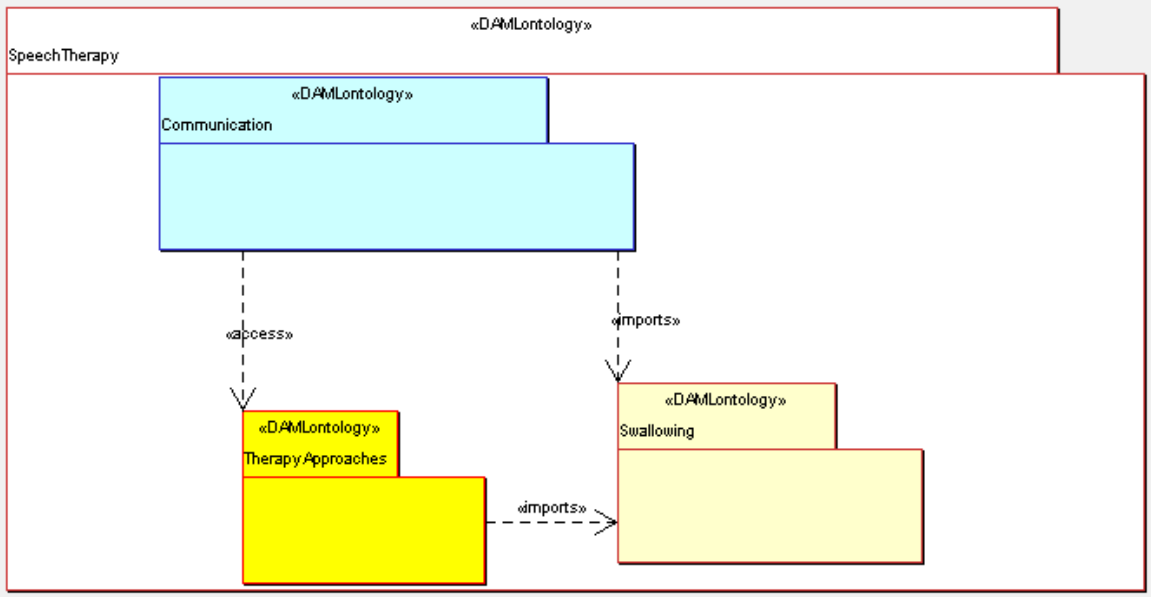

Figure 5.1 The interaction of different packages in PDSpeechtherapy

5.2.1 Communication

As shown in Figure 5.2, the Communication subsystem consists of an abstract class called `Communication`. The classes in UML correspond to the concepts in ontology, while the attributes in the classes correspond to the Property in the ontology. The inheritance of the concepts is represented by generalization/specialization in UML [122]. In our case, disjoint and unionOf concepts were represented by UML extensions.

An abstract class, represented in italics in the diagram, is essentially a place holder that needs to be replaced by the subclasses, `Language`, `Prosody`, `Intelligibility`, `RateControl` and `NonVerbalCommunication`. The three fields of 'needs', 'goals' and 'carerneeds' of `Assessment` of the patient are dependent on the `Communication` of the patient and this is indicated by the broken arrow symbol.

Packages	**Functionality**
Communication	Describes the kind of Communication, e.g. Prosody, Phonation, RateControl, Respiration, Loudness, FacialExpression, Writing and Articulation necessary for effective control of speech (Figure 5.1)
TherapyApproaches	The kinds of therapy approaches, viz., VoiceExercise, BreathingExercise, FacialExercise, Intonation, Loudness, RateControl and the CommunicationAids,both HighTech and LightTech, which acts as the Intelligibility of the therapy (Figure 5.2)
Swallowing	This package outlines the Equipments, the people responsible for the administration of Posture, Nutrition, Surgery, DietaryStrategies and Medication, along with the Symptoms and Assessment of the problems encountered in Swallowing (Figure 5.3)

Table 5.1: Packages for PDSpeechtherapy

`Prosody` and `NonVerbalCommunication`, parent class for `Writing` and `FacialExpression`, are disjoint classes and these are represented by the UML extension of stereotype, <<daml:disjointWith>>. The disjoint relationship between `NonVerbalCommunication` and `Phonation` is also expressed similarly. Concepts that are disjoint cannot have the same instance and adding such constraints to the model and hence the ontology adds to the consistency. `Phonation`, while being dependent on Respiration, is also affected by the class `Loudness`. The filled-in black rhombus, known as compositional relationship, indicates that while the action of `Loudness` is independent of both `Respiration and Phonation`; they themselves are affected by `Loudness`. The scope of the attributes and the classes are of the type public since DAML+OIL unlike UML only supports visibility of type public.

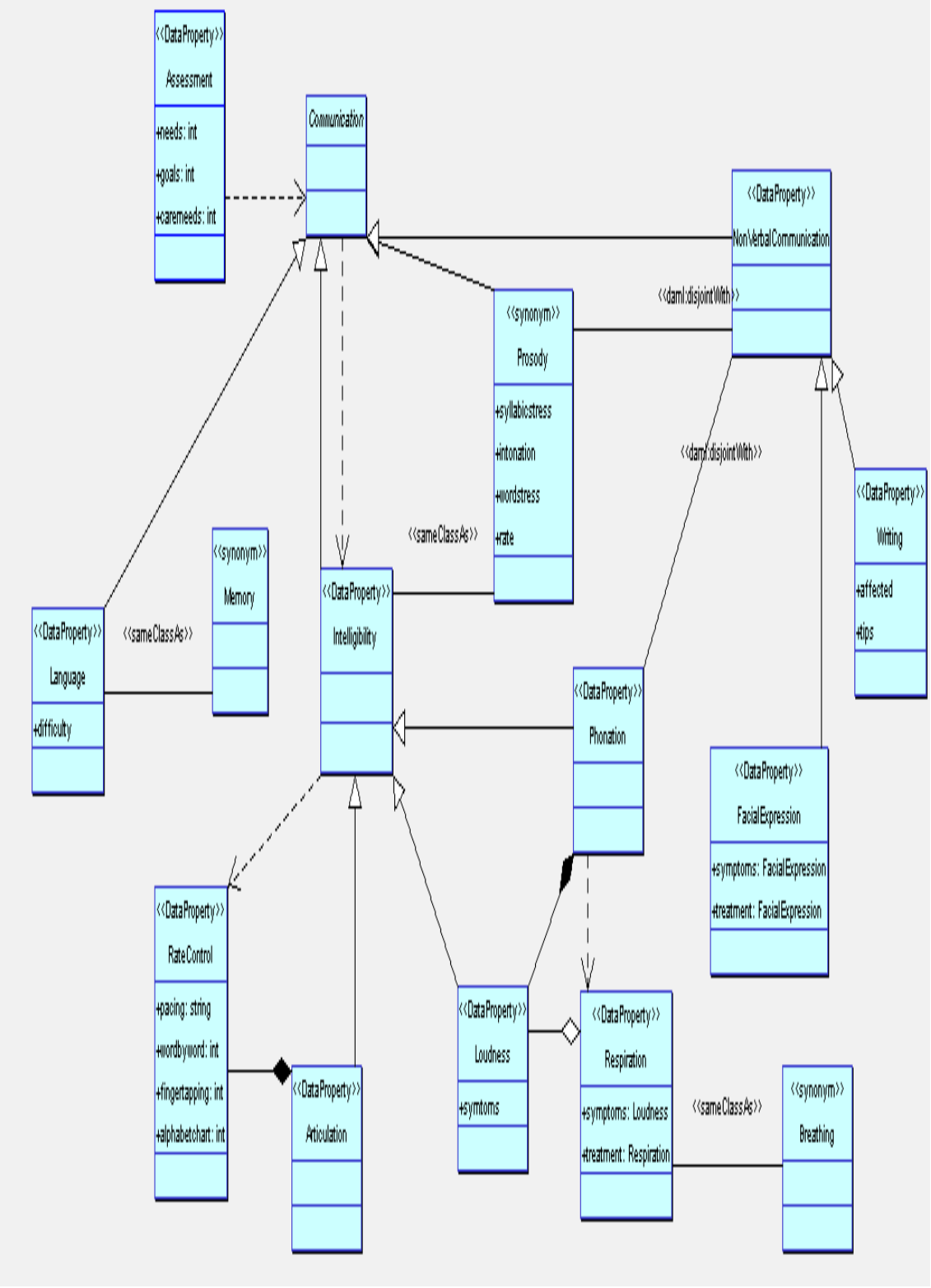

Figure 5.2 Communication subsystem for PDSpeechtherapy

The class `Prosody` describes the 'syllabicstress', 'intonation', 'wordstress' and the 'rate' at which `Intelligibilty` of the patient's speech is determined.

Intelligibilty is associated with Prosody since it is a synonym and hence belongs to the same class as Prosody. This is represented by the stereotype of <<daml:sameClassAs>>. Articulation exists to be captured by the range of 'pacing', 'wordbyword', 'fingertapping' and 'alphabetcount' of the RateControl in the speech of the patient. The relationship between concepts is represented by Properties and in the case of DAML+OIL it is mapped to daml:ObjectProperty whose range can be of one Individual while daml:DataProperty can be only one Datavalue.

The class Respiration, which has a synonym of Breathing, describes the 'treatment' and the 'symptoms' associated by the compositional relationship of Loudness against the attribute 'symptoms' which is of type String. A String is a container for characters and as such needs to be parsed to extract any meaning. Since parsers vary depending on the tool, modeling such a feature requires the data type for such an attribute to be assigned to the range of Loudness. The semantics of 'symptoms' can then be identified by the range to which it is attached. This is because it is an attribute which is also present in Writing and FacialExpression, two subclasses of NonVerbalCommunication.

5.2.2 TherapyApproaches

The Intelligibility of the speech therapy is determined by the different kinds of CommunicationAids, both LightTech and HighTech. The self-reference on CommunicationAids allows one or more 'aidofferings' to be represented without the need to set parameters separately. Both LightTech and HighTech also references itself for the one or more technologies that both of them can offer. Intelligibility is an abstract entity and, is therefore, instantiated by the sub-classes of FacialExercise, IntonationandStress, Articulation, BreathingExercise and VoiceExercise. The dependency of Loudness on BreathingExercise is also shown in the model. IntonationandStress captures the rationale behind the Intelligibility by describing the 'wordstress', 'sentencestress' and the 'intonationpatterns'.

The 'weakvoice' and the 'therapyapproach' of the `VoiceExercise` is dependent on the ordered set of the properties of 'breathcontrol, 'coordination' and 'breathingpattern' for `BreathingExercise`. The involvement of the Carers and their associations with the Groups in the therapeutical treatment of speech is also shown in the model. This is illustrated in Figure 5.3.

5.2.3 Swallowing

There are 10 classes associated with this subsystem. `Assessments` is associated with making both the 'informal' and 'formal' the 'observation' in describing the 'casehistory' of the patient against the `Symptoms` that hold information on the 'oral', 'pharyngeal' and 'oesophageal' aspects of the problems of `Swallowing` that is responsible for the speech dysfunction in PWPD.

The `Management` holds the key to different kinds of 'managementtypes' that is then passed to the subclasses of `Posture`, `Surgery`, `Nutrition`, `DietaryStrategies` and `Equipments`. The kind of 'speechlanguage' that is regarded as the dietary strategy is dependent by the `Medication`. `Equipments` hold a reflexive relationship to itself by the use of one or more 'equipmenttypes'. `Nutrition` and `DietaryStrategies` are related to each other since a 'dietician' can prescribe one or more strategies of 'speechlanguage'. This is exemplified in Figure 5.4.

The different packages for PDPhysiotherapy and PDDiet and their corresponding functionalities are described in tables 5.2 and 5.3 respectively.

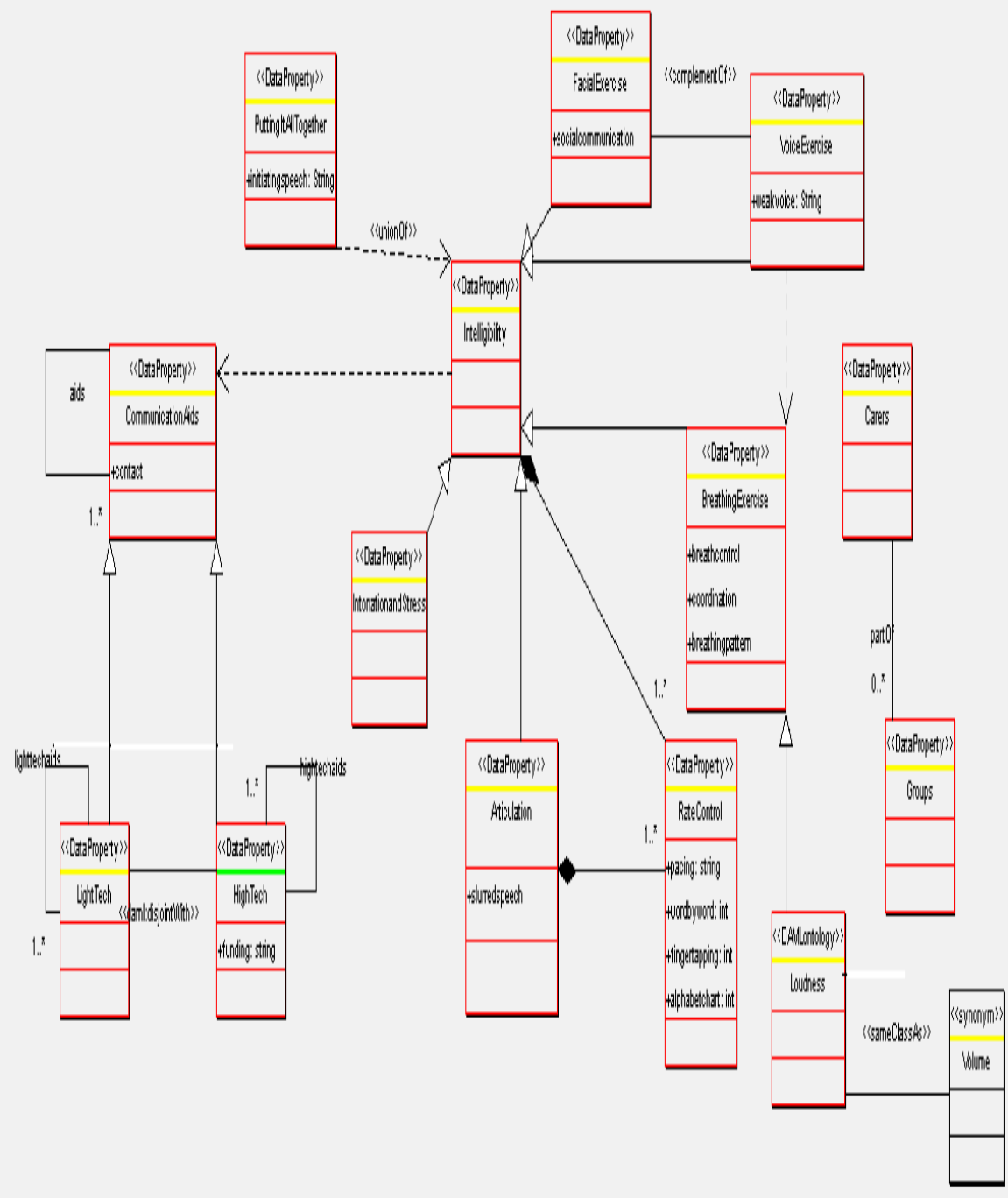

Figure 5.3 TherapyApproaches subsystem for PDSpeechtherapy

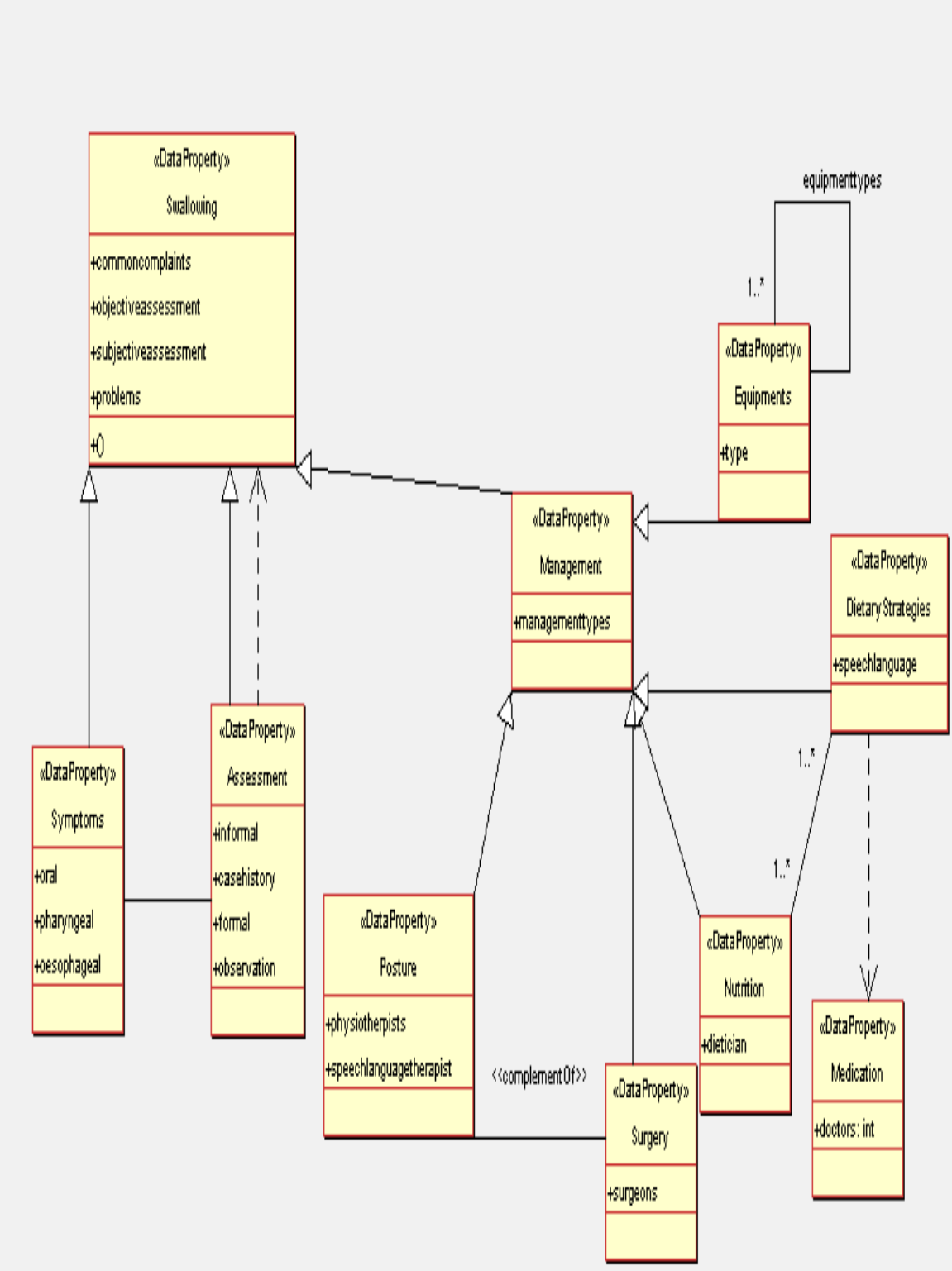

Figure 5.4 Swallowing subsystem for PDSpeechtherapy

Packages	**Functionality**
Services	The different kinds of services offered by the Physiotherapists (Figure 5.5)
Management	The techniques and the strategies followed by the Physiotherapists in consultation with Carers for PWPD (Figure 5.6)
AssessmentAndOutcome	Measures the Outcomes, Timing, CarerNeeds and DecisionMaking for the AssessmentAndOutcome of PWPD (Figure 5.7)
TeamApproach	The TeamApproach deals with the Communication of the Members, the Links, the interaction between the Primary_health_care_teams, Hospitaloutreachservices (Figure 5.8)
Information	The CarerInformation and the PatientInformation for Physiotherapists (Figure 5.9)

Table 5.2: Packages for PDPhysiotherapy

Packages	**Functionality**
BalanceOfGoodHealth	Describes the different kinds of foods, like ProteinFoods, DairyProducts, StarchyCarbohydrates, FruitVegetables, Fluids and FattySugaryFoods are given to PWPD (Figure 5.10)
FoodSupplements	Outlines the Prescribable and Nonprescribable food along with the different FoodFortification (Figure 5.11)
VitaminsMineralsAntioxidants	Contains the essential Vitamins, Minerals and Antioxidants (Figure 5.12)
EatingPlan	Describes the different Meals available, the cause for Constipation and the Medication (Figure 5.13)

Table 5.3: Packages for PDDiet

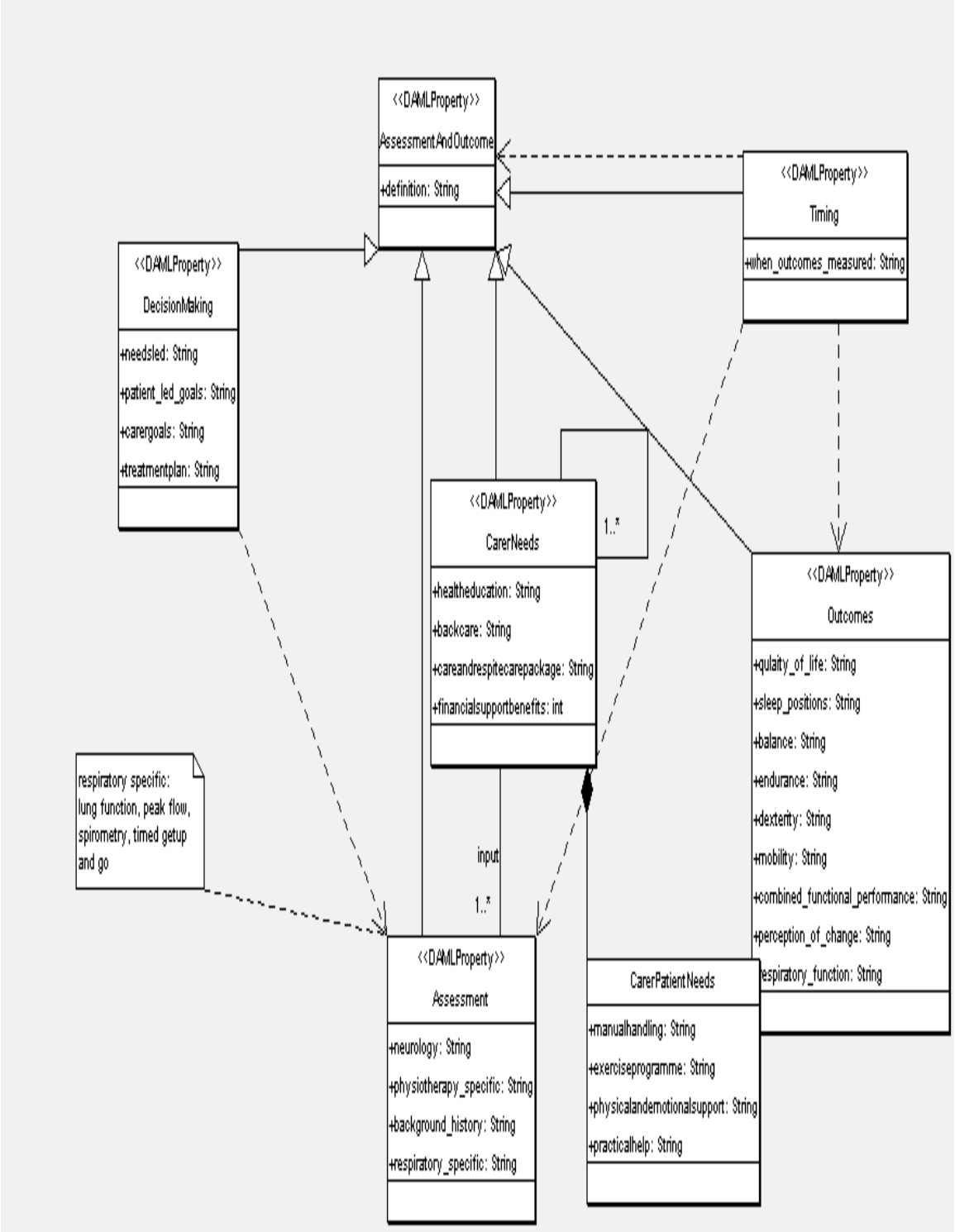

Figure 5.5 Services subsystem for PDPhysiotherapy

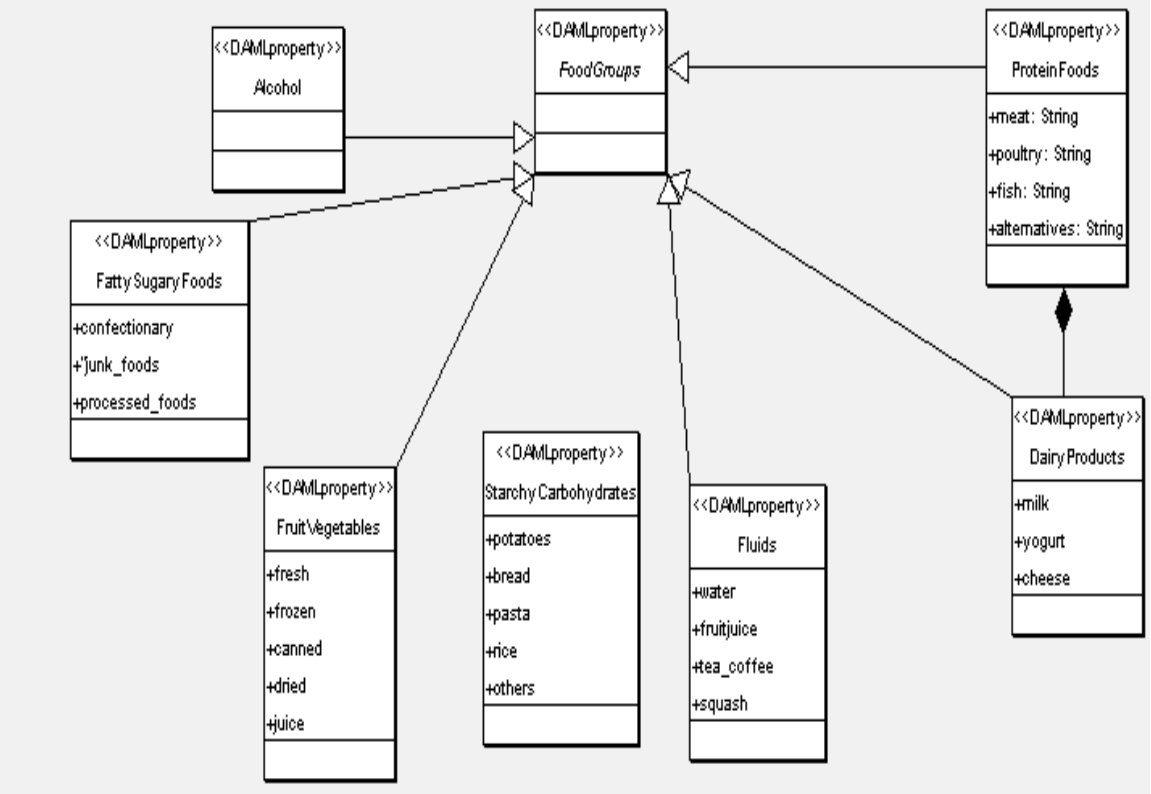

Figure 5.6 BalanceOfGoodhealth subsystem for PDDiet

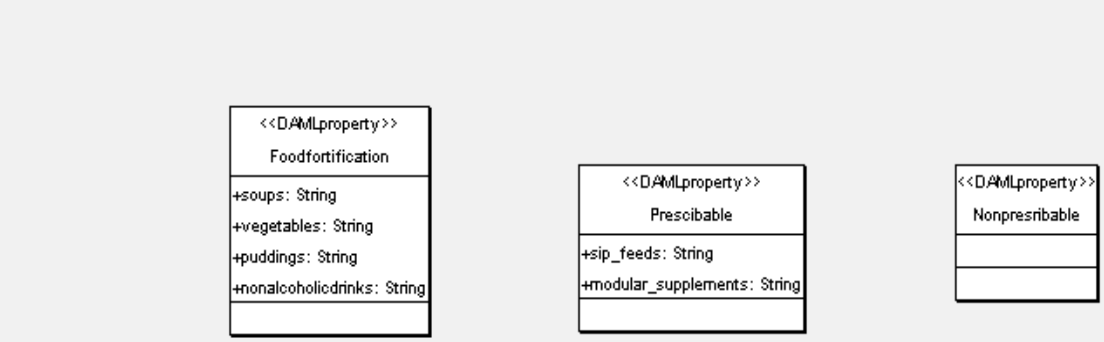

Figure 5.7 FoodFortification subsystem for PDDiet

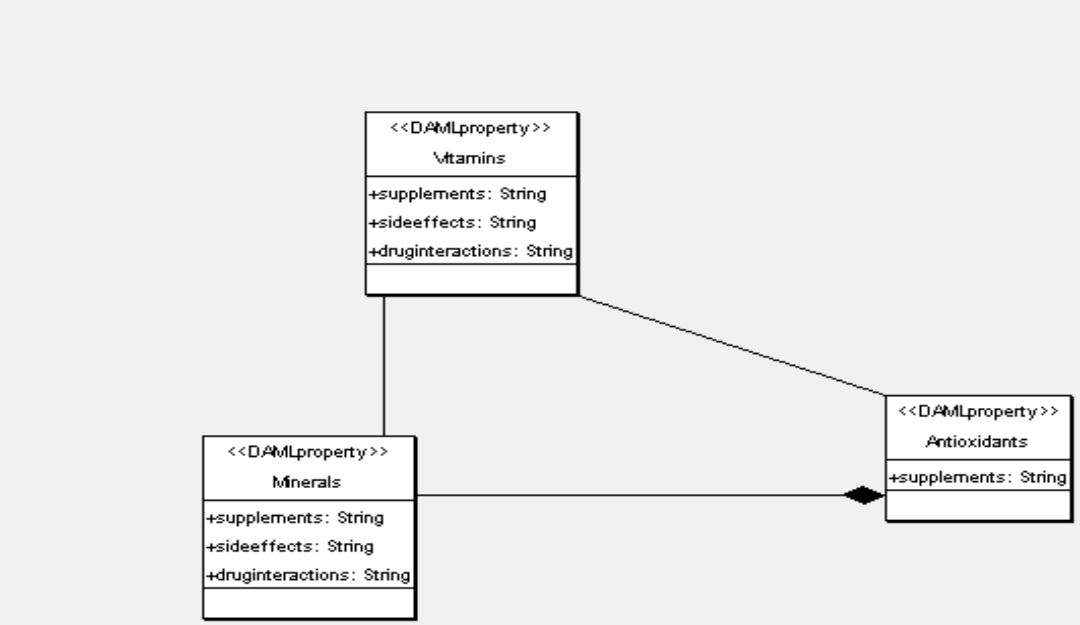

Figure 5.8 Vitamins subsystem for PDDiet

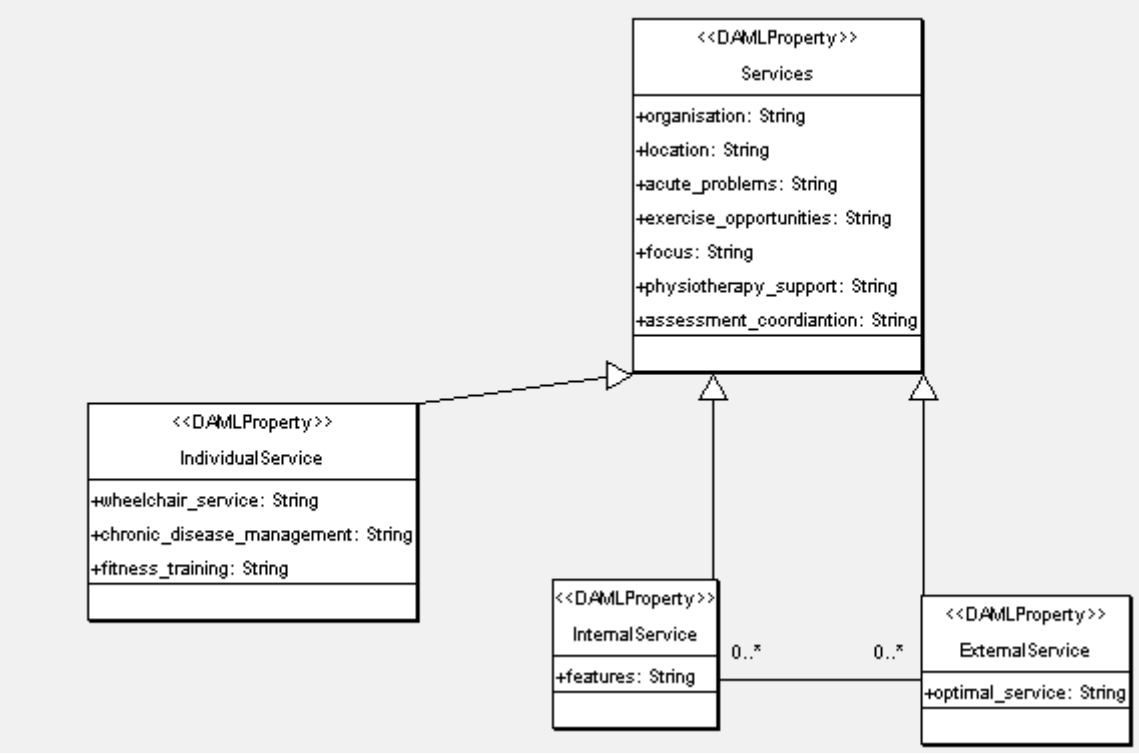

Figure 5.9 Services subsystem for PDDiet

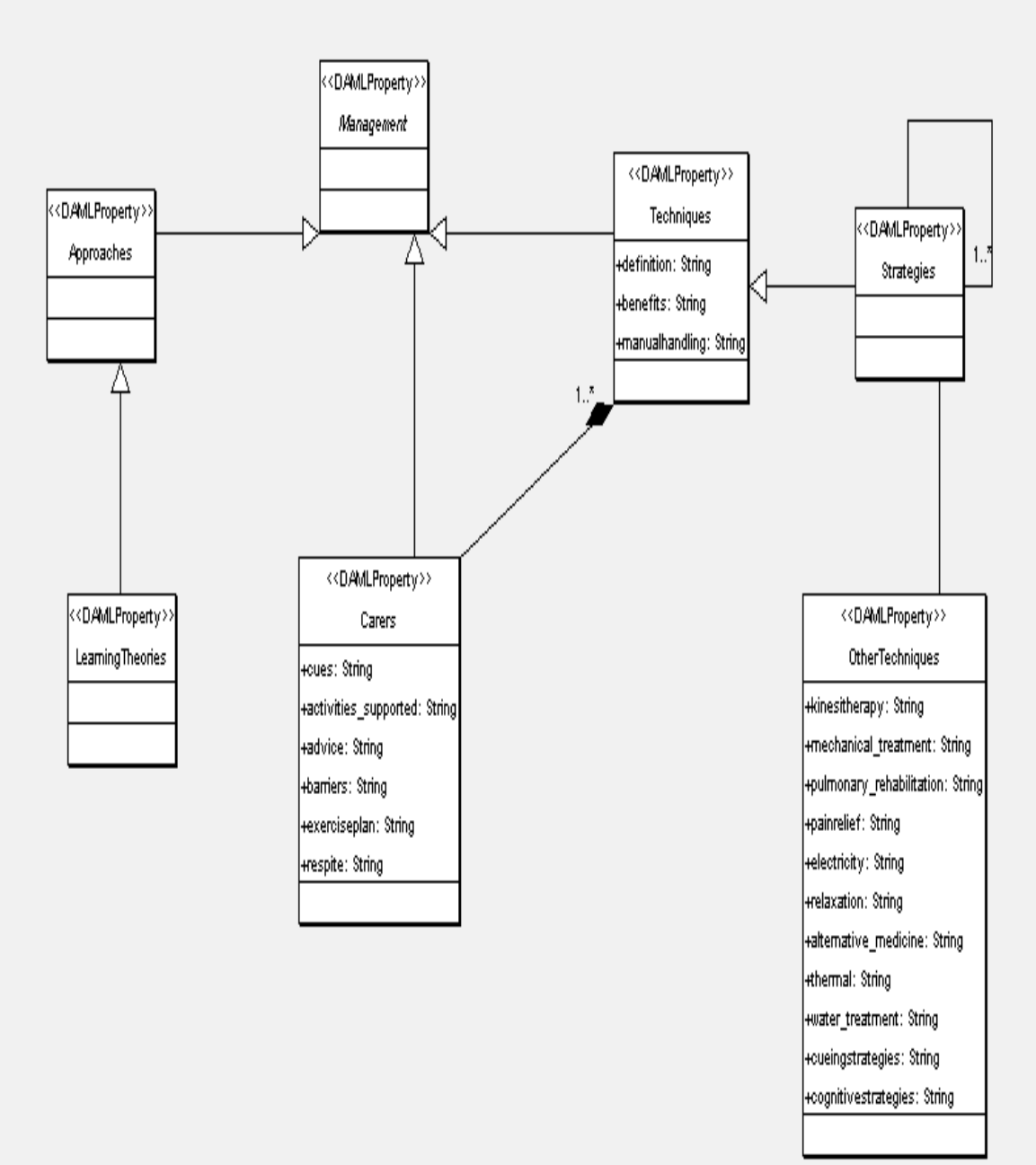

Figure 5.10 Management subsystem for PDSpeechtherapy

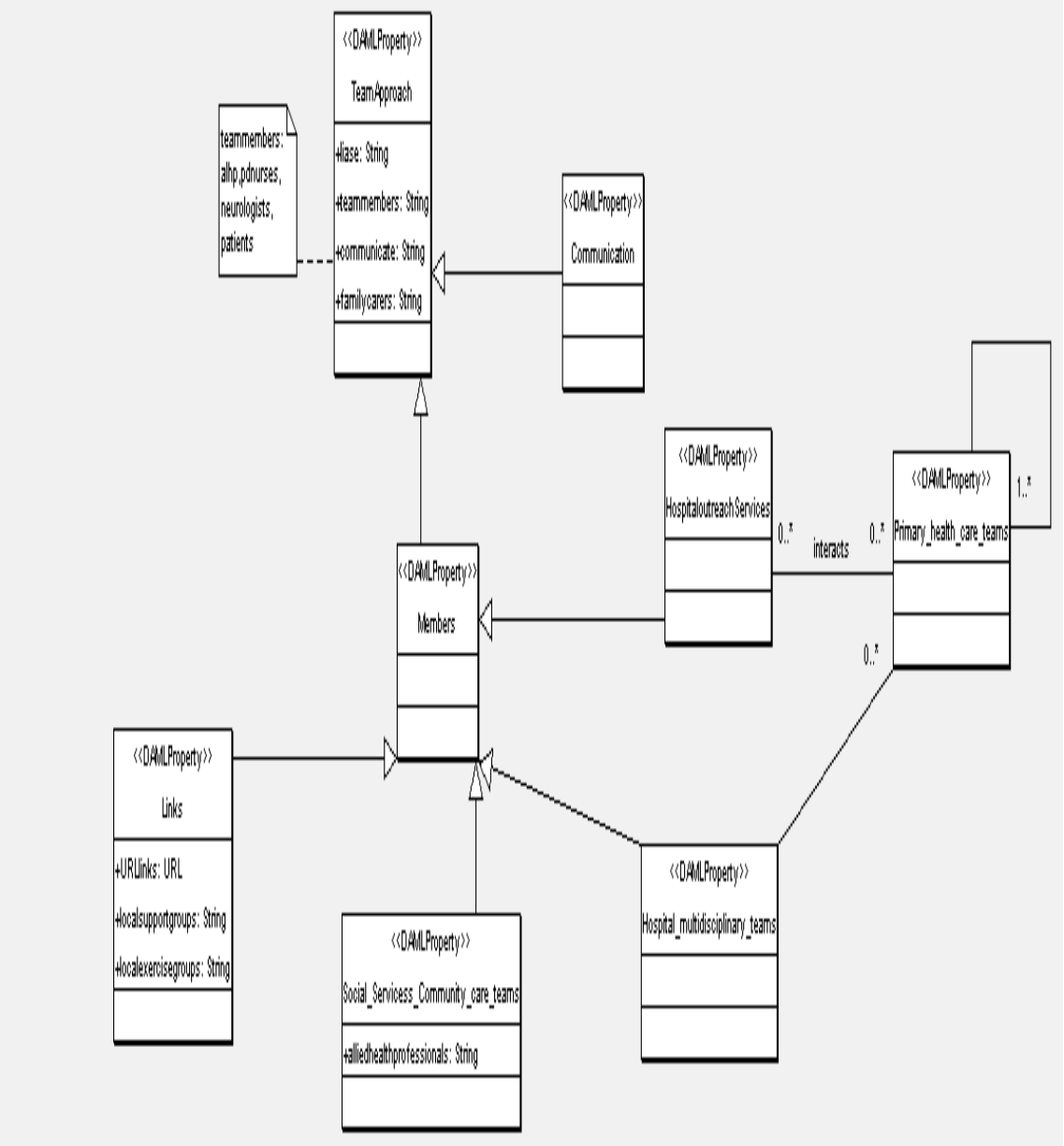

Figure 5.11 TeamApproach subsystem for PDSpeechtherapy

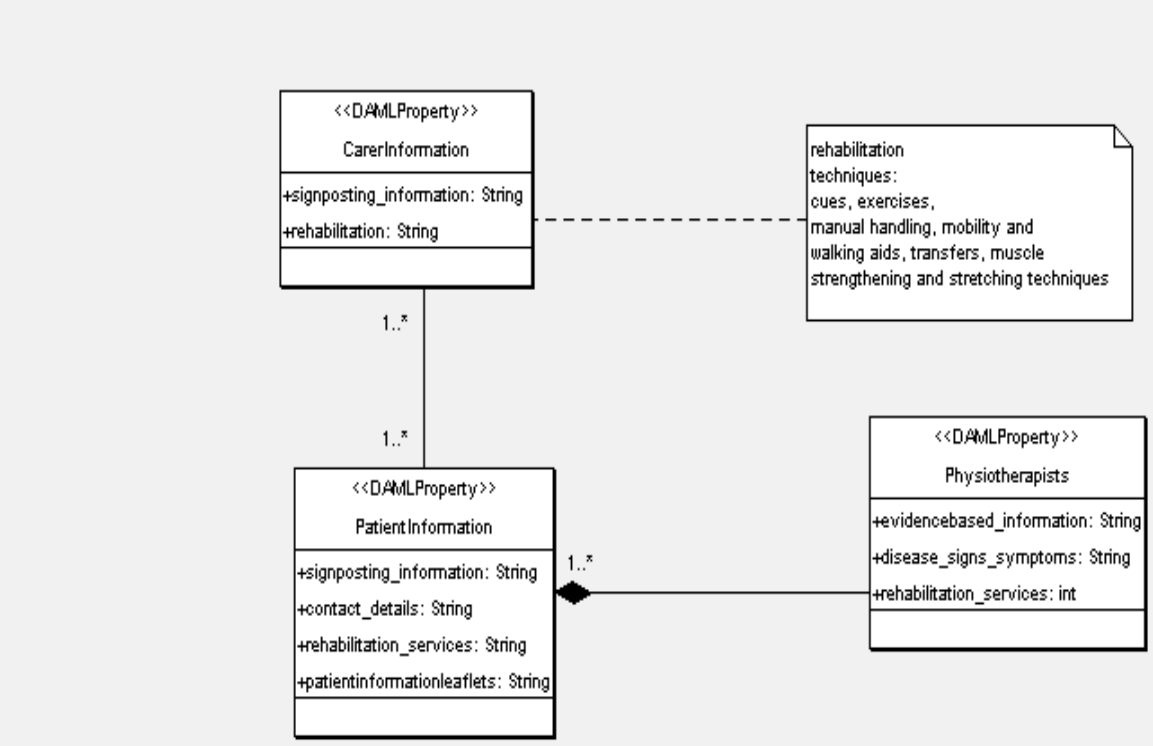

Figure 5.12 Information subsystem for PDSpeechtherapy

5.3 Conclusion

In this chapter, the modeling of a knowledge based system on PD comprising the knowledge bases of the components of PD like physiotherapy, speech and language therapy and diet was achieved by extending the UML profile. The structure of the conceptual knowledge of each of the knowledge bases was modeled using the class diagram. The vocabulary of UML was used to map to the semantics of the ontological language for DAML+OIL while describing the formal semantics for the domain for that part of the knowledge component of PD.

The conceptual layer for the knowledge base, for example in Speech and language therapy (PDSpeechtherapy), can be enhanced by adding subclasses since no UML constraint was added in generalization/specialization relationship. This was intentional since any new knowledge in the field can then be added by subsuming new concepts to the parent ones. The domain lexicon of the ontology was also added by classifying them as synonyms in the class diagram. The simplicity in which the model was

developed added to the benefit of both the knowledge engineer and the domain experts during the knowledge acquisition phase. The model was developed in UML to generate DAML+OIL format but can also be used to generate Java classes. As such, the model can serve to integrate both the information and the knowledge system in an enterprise system for PD.

The next chapter describes the development of the ontologies for the different knowledge base systems using the process of knowledge map. The knowledge bases are then mapped and merged.