A Resource Flow Approach to Modelling Care Pathways

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Abstract. Attempts to extend process management to support pathways in the health domain have not been as successful as workflow for routine business processes. In part this is due to the dynamic nature of knowledge-intensive work such as care pathways: the actions performed change continuously in response to the knowledge developed by those actions. Also, care pathways involve significant informal communications between those involved in caring for the patient and between these carers and the patient / patient family which are difficult to capture. We propose using an approach to supporting care pathways that embraces these difficulties. Rather than attempting to capture every nuance of individual activities, we seek to facilitate communication and coordination among knowledge workers to disseminate knowledge and pathway expertise throughout the organization.

1 Introduction

Connected Health encompasses terms such as wireless, digital, electronic, mobile, and tele-health and refers to a conceptual model for health management where devices, services or interventions are designed around the patient's needs, and health related data is shared, in such a way that the patient can receive care in the most proactive and efficient manner possible [1]. All stakeholders in the pathway are 'connected' by means of timely sharing and presentation of accurate and pertinent information regarding patient status through smarter use of data. Essentially "Connected Health" is the utilization of "connecting" technologies (i.e. communication systems – broadband, wireless, mobile phone, fixed phone lines), medical devices for healthcare applications and healthcare information systems. In addition, technologies relating to sensors, alert systems, vital sign monitoring devices, health informatics and data management systems are also fundamental to the development of Connected Health solutions.

These Connected Health solutions provide an opportunity to establish new care pathways and care delivery mechanisms. Care pathways, traditionally focused in primary and secondary care, are extending into the community. Standards of care, conventionally maintained and reinforced in a hospital/clinic setting, must now be supported in a community setting and encompass the new information flows from Connected Health solutions. This affords a significant opportunity to improve care pathways and develop best practices around Connected Health solutions.

As a model for healthcare provision, Connected Health offers many potential benefits. However, the conceptual shift from a model of healthcare where patient care is provided by an individual doctor to a model where care is provided by a team of heath care professionals also poses many challenges. It comes from teams of healthcare professionals who can have access to a lot of, often, too much, information. These healthcare professionals work together to understand prevention and treatments, and often use individual patient data, aggregated data and information from multiple sources. Patients may be using medical devices from mobile phone applications to regulated monitors, which are also data collection points. The difficulty healthcare professionals are faced with is how to use this data to make informed decisions about the care pathway which the patient should follow to ensure that preventions and treatments are efficient and effective.

In this paper, we report on applying a modelling approach to define care pathways and information flow in a Connected Health environment. The model specification can then be parsed and interpreted by a pathway support system. The modelling approach enables pathways to be modelled as independent “pathway fragments” representing activities performed by a single actor. Each fragment is a specification of the control flow from one action to the next that leads to the completion of an action. Coordination among concurrent activities performed by different actors is modelled as resource flow while dependencies among coordinated activities are represented by the resources shared by concurrent activities. This work contributes to a larger project which seeks to model workflow and information flow in connected health settings [2].

In Section 2 we provide a background to applying this approach. In Section 3 we show the rational and application of the approach using a simple example. In Section 4, we describe an implementation of process modelling using an idealized evidence-based pathway for a dementia patient. Finally, in Section 6 we describe our conclusion.

2 Workflow in Healthcare

The healthcare domain relies on knowledge intensive work. Knowledge intensive work is different from routine work in that actors may perform knowledge intensive actions in different ways, depending on their intuition, preferences, and expertise. For example, novice actors who are performing the work for the first time may not have any knowledge about how to do the work. More experienced actors who have done the work before have some insight about how things should be done. Finally, there are experts, who know the process thoroughly and can readily improvise new solutions to problems. Due to this difference in their respective knowledge levels, different actors may do the same work in different ways. Consequently, the amount and nature of guidance required while doing the work is different. Thus, a modelling language for supporting knowledge intensive work must be flexible.

Continuous change is also a key issue in the health domain. Changes may result from the introduction of new devices, new software applications, new personnel, or new guidelines, regulatory requirements or standards. Still other changes come as reactions to errors that have recently occurred locally. In part, this is due to the dynamic nature of such activities: actors in knowledge-intensive environments continually adapt their activities to reflect increasing understanding of the problem at hand, which understanding results from performing the knowledge intensive activities. Thus, the performance or enactment of knowledge-intensive work processes involves a continuous cycle of planning, action, review, and refinement. Any representation of workflow in healthcare must be able to handle this continuous change.

A workflow modelling language is any artificial language that can be used to express information or knowledge or systems in a structure that is defined by a consistent set of rules [3]. There is an enormous variety of modelling languages in existence. Modelling languages can be graphical (e.g. UML [4]), formal (e.g. Petri-Nets [5] or Little-Jil [6]), or control flow (e.g. PML [7, 8]).

2.1 Formal Modelling

Formal modelling processes is one paradigm for describing processes [9, 10]. This approach relies on rules or logical descriptions to describe the actions and then generates a model from the dependencies specified in the actions. The main advantage of this approach is that the modeller need only specify individual actions, and the associated tools will automatically generate a model with consistent dependencies. Two of the most popular formal modelling approaches in healthcare are Petri-Nets and Little-Jil.

Petri-Nets [5, 11] is an example of a formal modelling language and uses constructs underpinned by a mathematical model [12] to describe workflow. The advantages of Petri-Nets are the explicit synchronisation and concurrency, plus mechanisms for sequencing and routing of tasks in workflows. However Petri-Nets has a number of disadvantages [13] not least of which is the difficulty in representing data-flow. It is also difficult to model conditions that relate to attributes and information objects. These are required for modelling collaborative workflows that are typical for integrated health information systems for the effective sharing of health information and care resources.

Little-Jil [6] is formal modelling language based on co-ordination of agents. Little-JIL is based on a graphical representation of processes. This graphical representation is used to describe the order and communication between actions. A compiler is developed to translate a Little-JIL model into a finite-state machine. Properties of a workflow are specified as a property of the state machine. Finite state machine model checkers are used for verification of the model.

Through both Petri-Nets and Little-Jil are formal approaches they have a graphical representation. The advantage of this approach is that the process is displayed as a graph or flowchart that can be easily followed. However, the advantage of a graphical display erodes as the detail of the model increases.

The complexity of the language should not prevent a person without strong technical background from using the language. A non-technical person should be able to model the process without being encumbered by the syntactic requirements of the language. However, both Little-Jil and Petri-Nets assume some level of technical familiarity using syntax such as ‘interface’, ‘agent’ and ‘exception’.

For the modeller, formal modelling approaches can make it difficult to control the order of actions in the process. If two steps are independent, but the modellers wants them to be performed in a sequence, then a false dependency must be introduced in order to achieve the desired results, which adds an unnecessary layer of complexity. This can produce undesirable results especially at high levels of abstraction. The semantics to provide control to a process are too low-level to adequately control an abstract model. If no rules are specified, then it is difficult to generate a model that accurately depicts the process at a high-level.

Common formal modelling approaches to adding flexibility is enabling exception handling capabilities. The focus is on changing the running instances of the process model to handle exceptional situations which may or may not be anticipated and which require the actor to deviate from the normal flow of work. The idea is that once systems have such capability, they will be able to handle dynamic work processes. Little-Jil uses exceptions to increase flexibility. Petri-Nets have been adapted to allow for exceptions [14]. Recursive Workflow Nets (RecWF-Nets) [15] are another formalism for the modelling and analysis of flexible clinical pathways. They allow users to deviate from the pre-modelled process plan during run-time by offering other alternatives (creating, deleting or reordering some sub-processes).

However these approaches are counterintuitive to how people think about processes. The order in which actions are performed is a primary concern when defining a process and the modeller should be able to control it. Therefore, rather than implementing the care pathway with a formal modelling language, the language we advocate is control-based with a resource flow focus, an approach called PML [7, 8].

2.2 Process Modelling Language

PML (Process Modelling Language) enables control to be specified by the modeller, which allows her to describe the flow of control in the pathway. This method can be used to model abstract pathways, detailed pathways, and every layer of abstraction between the two [16]. At a high level of abstraction, the control is sequential, which allows the modeller to imply the dependencies without actually having to specify them. If it is later decided that the model should be more specific, the actual dependencies can be introduced. This method is more intuitive and reflects the steps that healthcare professionals normally take.

Previous work has demonstrated the value of resource flow models for documenting and analysing knowledge-intensive work [7, 17]. A resource flow model does not seek to capture every detail and nuance of a knowledge-intensive process; rather, it documents the major activities of a process, and the primary sequence in which they are performed through the production and consuming of artefacts. Using a resource flow specification of the pathway, the current state of the pathway can be inferred by observing the current state of the artefacts in the environment. Then, when the actor asks for advice, the pathway support system uses this inferred state and the process specification to provide guidance on what to do next. Since there is no enforcement of the nominal flow of actions specified in the process model, deviations can be easily supported.

Modelling pathway using resource flow models yields several benefits [16]:

- Resource flow models are low-fidelity, easy to specify, and can be generated rapidly.
- A resource flow model still captures the essential facets of a process, especially the resources consumed and artefacts produced by a given set of activities.
- Because they seek to represent only high-level detail, resource flow models are relatively stable; that is, they continue to be accurate descriptions of the high-level process, even as the details of process activities evolve in response to knowledge and experience gained with the problem.

Ultimately, we will use resource–flow care pathways to develop a support system that will guide stakeholders through pathway execution. For example, when a doctor requests assistance on the next steps for a suspected dementia case our model should provide them support in doing this. It is currently difficult for medical professionals to stay up-to-date on the latest recommended protocols without such assistance. Providing updated process models that can provide on-line guidance would help address this problem.

Our proposed approach targets the facilitation of communication and collaboration among knowledge workers to disseminate process expertise as widely as possible. In this approach, actors are given high-level guidance about what activities to perform, and how to perform them, through the use of low-fidelity process models. These specify a nominal order of actions, but leave actors free to carry out their activities as their expertise and the situation dictates.

In the following section, we will demonstrate the potential for this type of low-fidelity control flow modelling for care pathway representation.

3 Resource Flow Pathway Modelling

An example of a low-fidelity model depicting a pathway is shown in Figure 1. This model shows the nominal sequence of activities involved in the treatment of a set of symptoms: the patient presents himself to a specialist clinician, an examination is undertaken and after which a diagnosis is made followed by a course of treatment.

This model captures both the important activities in a clinical treatment, and the main sequence, and is thus useful for discussing the pathway. But it does not capture all of the possible transitions between activities. Many experienced healthcare professions may delay diagnosis, may refer the patient to another clinician, or may attempt to treat patient symptoms if diagnosis is not possible. Occasionally, it is necessary to iterate over the `examine` and `diagnose` cycle – as a clinician attempts to diagnose from the generic to the specific. Figure 2 shows these additional transitions, represented by dashed edges.

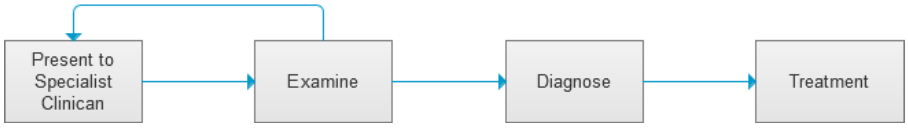

Fig. 1. Specialist assessment pathway

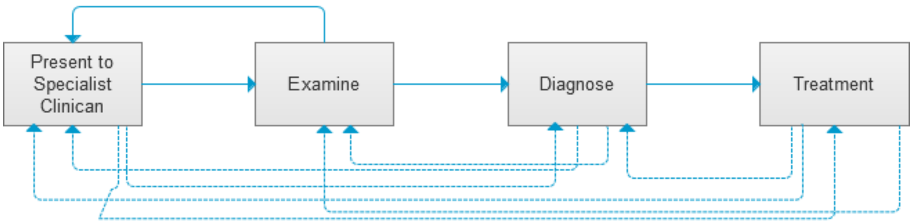

Fig. 2. Specialist assessment pathway, augmented.

While this depiction is more complete, in that it represents all of the plausible transitions between actions, it is not completely accurate. For example, although the graph shows a transition from "`Present to Specialist Clinician`" to "`Diagnose`", it is not possible to take this transition until the "`Examine`" step has been successfully completed at least once: "`Diagnose`" requires examination artefacts, which is the output of the "`Examine`" step. Further, it's not clear that Figure 2 is more useful than Figure 1. As a guidance tool, a novice clinician might find the numerous transitions confusing, while an expert would already know that these additional transitions are possible.

The modelling approach we have adopted is based on the notion of low-fidelity process models. A low-fidelity model seeks to capture the essence of a process, while abstracting away as many details as possible. The modelling language allows the modeler to capture both the nominal control flow (the solid edges in Figure 2), and the conditions that constrain transitions outside the nominal flow (the dashed lines in Figure 2).

A PML specification of the model in Figure 1 is shown in the following page. The nominal control flow is represented explicitly by the iteration constructs and the ordering of actions in the specifications. The constraints on other transitions are expressed by `provides` and `requires` statements. These are predicates that express the inputs and outputs of each step (action) in the pathway, and thus the pre and post-conditions that exist at each step in the pathway. Note that this simple specification captures the constraint that `Diagnose` cannot proceed until `Examine` is successful: the `Diagnose` action require a resource called `examinationArtefacts`, which is produced (provided) by the "`Examine`" action. Thus, until this action succeeds, `Diagnose` is not possible.

PML representation of Clinical Assessment Pathway

```
process ClinicalAssessment {
  iteration {
    iteration {
      action PresentToSpecailistClinician{
        requires { reportedSymptoms }
        provides { scheduleExamination}
      }
      action Examine {
        requires { scheduleExamination }
        provides { examinationArtefacts }
      }
    }
    action Diagnose {
      requires { examinationArtefacts }
      provides { diagnosis }
    }
    action Treatment{
      requires { diagnosis}
    }
  }
}
```

3.1 Modelling Parallel Pathways

A further complication in modelling the care pathway is that the clinical assessment pathway shown in Figures 1 and 2 does not exist in isolation. Other pathways produce and consume resources from this pathway, as depicted in Figure 4. This figure shows two cooperating pathways: the clinical assessment pathway of Figure 1 and Figure 2, and a parallel lab test pathway.

These pathways cooperate to result in an assessment for the patient: both start with some symptoms to develop their respective artefacts. In addition, the laboratory assessment pathway needs the output of the clinical assessment pathway (the examination artifact and the diagnosis artifact) to run laboratory tests. This dependency between the two pathways could be represented by an explicit link between the "`Treat`" and "`Run Tests`" actions (represented by the solid edge in Figure 3). But this approach has several difficulties.

First, it creates an explicit connection between the two pathways that does not always exist: healthcare professions could employ any of a number of different treatment pathways.

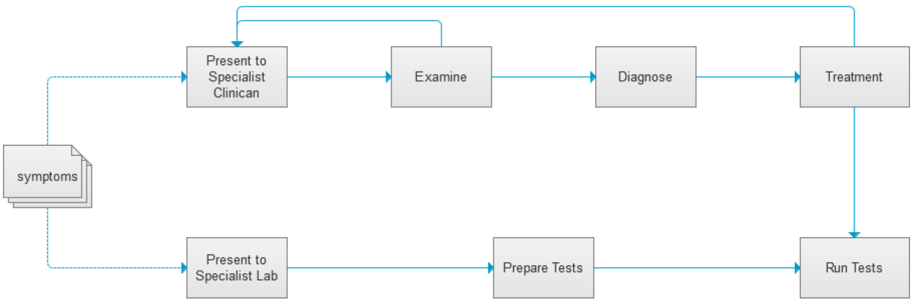

Fig. 3. Coordinated Pathways

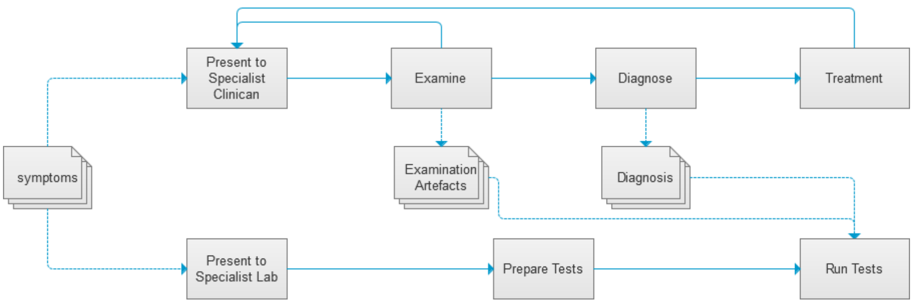

Fig. 4. Resource flow between pathways

Second, it requires both pathways to be maintained as a single model, which is often not the case. Different organizations are responsible for different pathways that they develop independently. Finally, it doesn't capture the true relationship between the pathways. Typically the laboratory assessment pathway requires a "`Diagnosis`" and "`Examination Artefacts`", which could, for example, include blood samples to run test so that the actual relationship is between "`Diagnose`" and "`Run Tests`" as opposed to "Treat" and "Run Tests." But the patient must have been examined before it can be accepted for testing so there is also a relationship between "`Examine`" and "`Run Tests`". From the test pathway point of view there is an "and" style relationship between "`Diagnose`" and "`Examine`", and "`Run Tests`".

The essential relationship between the two pathways is that the clinical assessment pathway produces examination and diagnosis artefacts for the lab pathway to test (Figure 4). It is not important to the laboratory pathway how the clinical assessment pathway diagnoses the patient or how they produce the examination artefacts. What is important is that they exist in a state suitable for the "`Run Tests`" action.

This relationship is represented in PML as the *PML representation of Laboratory Assessment Pathway*. This specification shows that the beginning of the laboratory assessment pathway depends on the availability of "`symptoms`". More importantly, the "`Run Tests`" action cannot begin until the "`Present to Specialist Lab`" and the "`Prepare Tests`" actions are completed.

Because the pathways are indirectly coupled, it is not necessary for all actions to be modelled, or enacted. Through a shared resource, enacted pathways can be coordinated with ad-hoc work or activities in another organization. Thus, the "`RunTests`" action can begin as soon as the "`examinationArtefacts`" and "`diagnosis`" resources are available, but these resources can be produced by any pathway, including a completely spontaneous ad-hoc pathway.

PML representation of Laboratory Assessment Pathway

```
process LabAssessment{
  action PresentToSpecialistLab{
    requires { symptoms }
    provides { testPlan }
  }
  action PrepareTests{
    requires { testPlan }
    provides { testSuite }
  }
  action RunTests{
    requires { testSuite && examinationArtefacts
      && diagnosis }
    provides { diagnosis.status == "tested" }
  }
}
```

4 Modelling Clinical Guidelines

In the initial year of the research we are focusing on the understanding and modelling of the clinical preventions, treatments and control of dementia in the elderly. Recently, the National Health Service in the United Kingdom has made the Map of Medicine (MoM) available to healthcare professionals.

The Map of Medicine [18] is a visualization of the ideal, evidence-based patient journey for common and important conditions that can be shared across all care settings. The decentralized nature of care pathways relies on the guidance of a defined pathway to provide cohesion between various stakeholders. The MoM is a web-based tool that can help drive clinical consensus to improve quality and safety in any healthcare organization. In the MoM the key interventions are described and references to the guidelines and the overall available literature are made available. The pathways can be one of the tools to organize daily clinical practice, based on the evidence-based content of the MoM.

The MoM care pathway for dementia has two components: assessment of dementia and management of dementia. The first entails detailing how dementia should be assessed and diagnosed. The second is based on managing dementia until end of life. Each stage is comprised of a series of actions related to fulfilling the next stage in development. The management of dementia pathway is given in Figure 5 and provides a summary of the actions involved. In the following section, we discuss our experiences in modelling this pathway using PML.

4.1 Modelling Map of Medicine Dementia Management

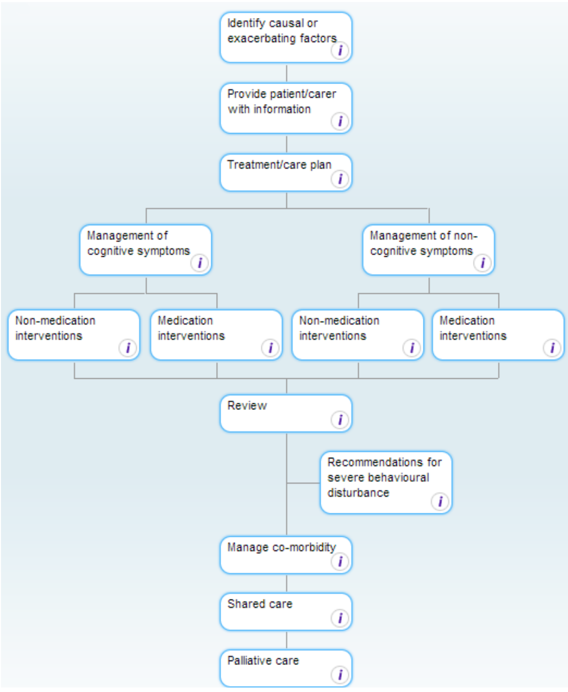

Fig. 5. Action flow in Map of Medicine

On first inspection of the map it is clear that the model is in a basic state in that it includes control and resources, but no attributes or expressions. Inconsistencies are typically introduced into a model because of a failure to specify requirements for an action. In PML, this translates to the failure to require or provide a resource in an action. Each graphical activity contains a detailed description of the underlying pathway. Interpreting a natural language pathway descriptions, such as that used by the MoM, is based on user interpretation.

Since the top level map is described graphically, we first captured the control flow as a PML model with empty actions. Abstraction and hierarchical decomposition facilitates developing the model incrementally. We had to continually make choices about the number of levels into which an action should be decomposed and about the level of abstraction that was required. A first pass was made to understand and represent the pathway only involving step decomposition and control flow.


Dementia Management
start
identify causal or exacerbating factors
provide patient carer with information
create treatment or care plan
formal review of care plan
assess carer needs
cognitive symptom mgt
non cognitive symptom mgt
non medication interventions
medication interventions
non medication interventions
medication interventions
obtain carers view
document symptoms
assess behavioural disturbances
record changes
monitor patients on medication
consider alt assessments
manage comorbidity
psychosocial interventions
end

Fig. 6. Resource flow representation of Dementia Management

When examining provided and required resources, the MoM pathway is discussed at two levels of detail. High level actions refer directly to activities (Treatment/care plan, Management of cognitive symptoms, and Management of non-cognitive symptoms) which are graphically illustrated in the MoM. The lower level activities are extracted from the pathway textual descriptions associated with the higher level activities.

The natural language description used allows lots of room for user interpretation in the description of activities. Artefacts are defined but never used, artefacts are required but never created, high level actions are explicitly documented but low level activities are implicitly defined.

By modelling the MoM an inconsistency can be observed between the MoM graphical representation and the flow of resources. For instance, the Review action in the map is represented as occurring once as part of a linear control flow. However the natural language description of the action talks about the action being "assessed and recorded at regular intervals" [18]. In Figure 6 this is represented as the Record Changes action and is iteratively modelled. A second instance and a sub section of the Review action describes the monitoring of patients at three month intervals: "continue to carry out 3-6 monthly review of disease progression", "consider alternative methods of assessment for patient". These two actions are represented iteratively in Figure 6 as "monitor patients on medication" and "consider alt assessments".

Resource flow errors fall into four categories: those requiring and providing no resources (*empty*), those only requiring resources (*black holes*), those only providing resources (*miracles*), and those that provide resources other than those that they require (*transformations*).

For example, the actions "Management of non-cognitive symptoms" and "Management of cognitive symptoms" do not require or produce any resources therefore we can class them as *empty* actions. However, both actions are filtering patients based on a set of symptoms. However the resource that is providing symptom information is omitted.

In the MoM *transformations* occur in the pathway. These *transformations* typically occur due to two possibilities: the *transformation* is correct and the pathway should not consider the created resource, or the *transformation* is indicative of a change to a resource that was not specified as a requirement to the action. The only possible way to determine the actual meaning is to carefully inspect the pathway description and the context of the *transformation*.

An example of a transformation is the "create_treatment_or_care_plan" action. The required resource is "patient_history" and the produced resource is "care_plan". Action "formal_review_of_care_plan" is an example of where a transformation is improper. Here rather than a transformation where a new resource is produced after "formal_review_of_care_plan" we consolidate resources to a single resource and using attributes. We can reconstruct the action and describe it more accurately as:

PML description of formal review action

```
action formal_review_of_care_plan {
     agent {person && carer}
     requires {care_plan}
     provides {care_plan.reviewed == "true"}
}
```

Though a report of an unprovided resource can mean a misrepresentation of process, it can also be indicative of a resource that should pre-exist the process. "`Identify_causal_or_exacerbating_factors`" requires the resource "`Guidelines_For_Treatment_Of_Patients`" but this is the first action in the MoM pathway which means the resource cannot be specified prior to its use. Therefore identifying resources that should be considered inputs to the pathway is a key predeterminant for pathway execution. Outputs to the process should also be specified.

Resources that are provided by an action but are not later used in the pathway could be the result of a misspecified resource or an action does not note that it requires a certain resource. "`care_plan`" in action "`monitor_patients_on_medication`" is produced but not consumed in the pathway.

Correcting the mistakes found in the previous revision results in a model that produces no errors when checked, which ensures that the model is satisfied with the way dependencies are built. Though this does not indicate that there are no problems in the pathway, the model errors have been effectively removed. The final model is shown in Figure 6.

Our experience suggests that these sorts of detailed and complex pathway models should be developed incrementally. This would allow high level, more-abstract views of the pathway to be validated before more-detailed models are developed. The scope and granularity of the model should be determined by the questions the model is intended to address. There is no doubt that detailed models require more effort to develop and maintain, but provide more definitive, in-depth feedback.

PML representation of Map of Medicine Dementia Management pathway

```
process Dementia_Management {
  action identify_causal_or_exacerbating_factors {
    requires { Guidelines_For_Treatment_Of_Patients }
  }
  action provide_patient_carer_with_information {
    agent {GP && patient && carer}
    requires {patient_record.Confirmed_Dementia  }
    requires {patient_record.requests_privacy == "false"
}
```

```
    provides { information_to_carer }
  }
  action create_treatment_or_care_plan {
    agent {memory_assessment_service}
    agent {GP && clinical_psychologiest && nurses && oc-
cupational_therapists && phsiotherapists &&
speech_and_language_therapists && social_workers && vol-
untary_organisation}
    requires { patient_history }
    provides { care_plan }
  }
  action formal_review_of_care_plan {
    agent {person && carer}
    requires {care_plan}
    provides {care_plan.review} /* XXX Maybe,
care_plan.reviewed == "true" */
  }
  action assess_carer_needs {
    agent { carer}
    provides {care_plan.respite_care}
  }
  branch  {
    branch cognitive_symptom_mgt {
      action non_medication_interventions {
  provides {support_for_carer}
  provides {info_about_servicesAndInterventions}
  provides {(optional) cognitive_simulation}
      }
      action medication_interventions {
  agent {specialist}
  agent {carer}
  requires {(intangible)carer_view_on_patient_condition }
  provides {prescription}
      }
    } /* end of management_of_cognitive_symptoms  */
    branch non_cognitive_symptom_mgt {
      action non_medication_interventions {
  agent {carer && patient}
  requires {(nontangible)non_cognitive_symptoms || (non-
tangible) challenging_behaviour}
  provides {early_assessment}
      }
      action medication_interventions {
  requires {(intangible) risk_of_harm_or_distress}
  provides {medication}
```

```
      }
    } /* end of management_of_non_cognitive_symptoms */
  } /* end cognitive/non-cognitive symptoms branch */
  action obtain_carers_view {
    agent {carer}
    provides {(intangible) view_on_condition}
  }
  action document_symptoms {
    agent {patient}
    provides {patient_record.symptoms}
  }
  /* optional, if required */
  action assess_behavioural_disturbances {
    agent {patient}
    requires {(intangible)
risk_of_behavioural_disturbance}
    provides {care_plan.appropriate_setting}
  }
  branch {
    iteration {
      action record_changes {
  agent {patient}
  provides {patient_record.symptoms}
  provides {(optional) medication}
      }
    }
    iteration  {
      action monitor_patients_on_medication{
  agent {patient }
  provides {(optional)care_plan.medication}
      }
      action consider_alt_assessments {
  requires {patient_record.disability || pa-
tient_record.sensory_impairment || pa-
tient_record.lingustic_problems || pa-
tient_record.speech_problems}
  provides {care_plan.alternative_assessment_method}
      }
    }
    iteration {
      action manage_comorbidity {
  /*requires { }*/
  provides {comorbidity.depression}
  provides {comorbidity.psychosis}
  provides {comorbidity.delirium}
```

```
  provides {comorbidity.parkinsons_disease}
  provides {comorbidity.stroke}
      }
      action psychosocial_interventions {
  requires {comorbidity.depression || comorbidi-
ty.anxiety}
  agent {carer}
      }
    }
  } /* branch */
} /* process */
```

5 Conclusion

The application of a low fidelity model does not seek to capture every detail and nuance of a knowledge-intensive process. Rather, it documents the major activities of a process, and the primary sequence in which they are performed. Our preliminary work offers considerable promise that low fidelity resource modelling approaches are very suited to modelling medical processes.

One of the benefits of a resource-flow approach is that you can ensure that each action's required resources are produced by some earlier action; otherwise, either there is a flaw in the model, or an input to the pathway. In the MoM we can assess were there cases where the natural-language description overlooked an action or failed to mention a resource that was required later in the pathway? This is one of the biggest benefits of creating formal models: they force a certain level of rigor and therefore examination that could otherwise cause flaws to be overlooked.

5.1 Future Work

By adopting a process modelling approach developed for the software development domain, we have described an approach for care pathway modelling. This approach to pathway modelling needs further evaluation with some optimisation for the health domain.

We will look at applying it to a large scale critical process from the medical domain. Currently we are involved in modelling dementia pathways, initially looking at clinical guideline based pathways by NICE [19] and Map of Medicine [18].

Other interesting issues include how to maintain coherence between the actual pathway and the pathway model. Medical guidelines change frequently, however, so at least the generic versions of these models would need to be updated regularly and then re-customized. Related questions revolve around the customization of the care pathways and the degree to which each local setting has to create custom pathways. In theory, for well-designed pathway models, the customization of a general pathway to a particular hospital setting should mostly involve changes to the low-level pathway steps.

5.2 Acknowledgements

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6 References

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