Abstract

This paper considers the juncture experienced between information modelling in theory and information modelling in practice. It identifies the basis of this juncture in an unsatisfactory ontological basis for information modelling. Using both the early and more recent work of Searle it establishes the need for information models to be framed in terms of communicative patterns significant within some delimited institutional domain. Such communicative patterns are visualised in terms of an innovative artefact known as a pattern comic. The propositional content of communicative acts within such patterns is then expressed as a set of binary relations, which can be transformed into various visualisations of an information model. Patterns of communicative action evident in the domain of medical emergency response are used throughout to illustrate this pragmatic approach to constructing information models.

Keywords: Information modelling; Speech act theory; Social ontology; Pattern comics; Binary relations

Introduction

Hay (1996) cogently sums up the central problematic faced by practitioners of information modelling, when he states: '*learning the basics of a modelling technique is not the same as learning how to use and apply it … [Information] modelling is particularly complex to learn, because it requires the modeller to gain insights into an organization's nature that do not come easily.*' Part of the attraction of information modelling is that it uses relatively few constructs. But breakdowns in design (Bødker and Grønbœk, 1991), make this seductively simple approach extremely difficult to apply effectively when engaging with instances of organisation.

As a research aim this paper reconsiders the difficulties experienced in the practical conduct of information modelling. I make claim that much of the problematic experienced with the conduct of information modelling in practice is due to a misconceived notion of the proper context for information modelling, which I shall refer to as institutional ontology. I propose a way of thinking about the nature of information models in relation to institutional ontology which helps resolve many of the difficulties experienced with conducting information modelling in practice. This leads me to develop an innovative approach to doing information modelling which does justice to this different way of thinking about the relationship between an information model and institutional reality.

I locate the basis for many of the practical problems experienced with this technique in the pragmatics of information models. Pragmatics as a term has at least two senses appropriate to understanding the nature of information models. In one sense, pragmatics (Yule, 1996) is used to denote a sub-field of linguistics and semiotics, particularly concerned with the relationship between signs and their use within context. It is in this sense that I utilise both the early work of Searle on speech act theory and his more recent work on social ontology. In another sense, pragmatics denotes the application of pragmatism (Bernstein, 2010) - that branch of philosophy associated originally with the work of Peirce, James, Dewey and Mead. The key principles of pragmatism are that human concepts are defined by their consequences, truth is embodied in practical outcome and learning is controlled inquiry, in which rational thought is interspersed with action (Baskerville and Myers, 2004). Although there is no direct relationship between pragmatics as a linguistic endeavour and pragmatism as philosophical orientation, there is evident common ground in the positioning of both epistemology and ontology in the centrality of action (Agerfalk, Goldkuhl, Fitzgerald *et al*, 2006, Agerfalk, 2010). I locate problems experienced with practical information modelling in a misconceived understanding of the relationship between the constructs of an information model and their proper context – namely the communicative pattern appropriate to some delimited institutional domain. This is an issue of pragmatics. But I also wish to focus upon the nature of information models as a way-station to institutional action. In this sense, I consider the pragmatic consequences of an information model.

Most current practices of information modelling either explicitly or implicitly utilise a view of reality consistent with that evident in the work of Bunge (Wand and Weber, 1990; Wand and Weber, 1995), in which institutional reality is considered an organised collection of objective 'things' of interest. Information modelling practice also tends to adopt a view of representation which proposes that statements in some formal language, such as those encapsulated in an information model, correspond to objective facts about some institutional domain. I shall refer to this framing of the information model as the conventional worldview.

I contrast the conventional worldview with an alternative worldview of information modelling which arises from the language/action tradition (Goldkuhl and Lyytinen, 1982; Lyytinen, 1985; Winograd and Flores, 1986; Lyytinen and Hirscheim, 1988; Iigand, 2003; Te'eni, 2006). This worldview proposes that natural language statements are performances of social acts and that the performance of such acts help constitute an institutional reality which is inter-subjective. This worldview further suggests a framing of an information model as a specification of the structure of terms used within acts of communication relevant to some institutional domain.

The conventional and language/action worldviews are useful for portraying alternative accounts of the nature of information models based upon different conceptions of institutional ontology. However, I shall argue that the more recent work of Searle, which is less well-considered in the Information Systems literature (Searle, 1995; Searle, 2010), provides a more sophisticated account of the nature of institutional ontology. For Searle, institutional ontology, as a type of social ontology, is not something fundamentally separate from the ontology of the physical world: the two constitute levels of ontology which are inherently inter-related. The approach I adopt here particularly utilises his concepts of status functions, constitutive rules and institutional facts to better demonstrate the positioning of the constructs of an information model against this more sophisticated account of institutional ontology.

I then propose an innovative approach to doing information modelling which does justice to this different way of thinking about the proper context for an information model. I start by representing the narrative of communicative action relevant to some institutional domain (such as medical emergency response) using a pattern comic. Within this artefact communicative acts are represented as comic cells enacted by named actors or roles and involving both communicative intent and communicative content. I then unpack the communicative content of each communicative act as a set of terms. These terms are collected together and used to form a set of binary relations which adequately describe the communicative pattern under investigation. This set of binary relations is used, in turn, to construct a visualisation of an information model.

Finally, I evaluate some of the consequences of this alternative way of thinking about and doing information modelling, namely, its basis in institutional action, and how it helps resolve many of the problems experienced with the conventional worldview of information modelling. I also

contrast my approach with some other modelling approaches sensitive to both a language/action and social ontology worldview. I conclude the paper with a summary of my work, a rendering of its key contributions and mention of one area for further research implied by Searle's (2006, 2007) notion of social ontology.

Approaches to information modelling

Davies *et al* (2006) find that information modelling is by far the most commonplace modelling technique adopted amongst the information systems practitioner community. Ways of conducting information modelling have remained relatively stable for over three decades but there are a vast number of ways of visualising an information model. To isolate and express the accepted elements of an information model separate from issues of visualisation, I turn to the theory of binary relations, originally proposed in the work of Frost (1982; 1983), and use it here as a canonical form for expressing an information model. A binary relation can be considered a triple of items, in which the first item is termed the subject, the second the relation and the third the object. The original theory of binary relations is useful because it can be shown that many representational formalisms, familiar within information modelling, can be reconstructed from these simple, atomic forms (Frost, 1983). I focus within the current paper purely on a set of constructs which can be mapped to those originally expressed by Chen (1976) for his entity-relationship model.

The core construct within information modelling is that of an entity or class, which can be defined in terms of its intension and/or extension. The extension of a class refers to the range of phenomena (instances) that the class in some way covers. The intension of a class provides its meaning by specifying the collection of properties that in some way characterise the phenomena in the extension. Three types of properties are particularly important in defining the intension of some class – properties of identification, attribution and association. Identification serves to distinguish between the instances of some class; attribution relates a class to its attributes, while association relates the instances of some class to the instances of some other class.

Consider a class which is critically significant to the central case considered in a later section – that of an emergency incident. I might choose to define an emergency incident as a series of binary relations, such as:

[Emergency Incident REFERENCE incidentNo]

[Patient REFERENCE NHSNo]

[Location REFERENCE locationRef]

[Emergency incident HASA start time]

[Emergency incident INVOLVES Patient]

[Emergency incident OCCURS Location]

…

The relation REFERENCE relates a class to an identifier. The relation HASA relates a class to its attributes while the relations OCCURS and INVOLVES are association relationships between an *incident* class, a *location* class and a *patient* class.

This conventional worldview of information modelling has achieved a level of formalisation through the so-called Bunge-Wand-Weber ontology (Wand and Weber, 1990; Wand and Weber, 1995; Wand and Weber, 2002), which was originally developed as a way of conceptually modelling information systems (Wand, Storey and Weber, 1999; Bodart, Patel, Sim *et al*., 2001; Weber, 2003). Bunge's ontology proposes that the world is made of concrete things that possess properties and that properties can be conceived of as functions that map a thing onto some value. Wand and Weber (1990), build upon this idea to propose that the things and their properties relevant to some domain may be modelled directly as constructs within an information model. They further propose that classes can be modelled as things with common properties, whereas associations are suitable for modelling binding mutual properties shared between classes (Wand and Weber, 1995).

Practitioners encounter substantial problems when they attempt to perform information modelling in practice (Bodart *et al*, 2001) using this worldview. Novices in information modelling experience considerable difficulty in turning problem descriptions into abstract representations (Batra and Davis, 1992). The 'quality' of conceptual models prepared by both novice and expert alike are frequently poor (Moody and Shanks, 2003). Also, users have difficulty understanding information models. Even Weber (2003) has questioned the typical practices by which information modellers tend to model information systems artefacts such as *orders* and *invoices* rather than the underlying phenomena on which such artefacts rely.

More recently, issues have been raised in relation either to the lack of theoretical foundation (Siau, 2003) or to the meta-modelling assumptions underlying conventional information modelling (Eriksson, Henderson-Sellers and Agerfalk, 2013). This echoes an emerging critique of the ontological foundations of information modelling. Wyssuzek (2006), for instance, cogently argues that Wand and Weber acquired the conceptual apparatus of Bunge's work without adopting its basis in dialectical materialism. Allen and March (2006) argue that Bunge's ontology is concerned with representing the world of material things that exist independently of human interpretation. It has little concern with the world of human intentions and meaning. This has led some to contrast the conventional view of information modelling with a worldview more sensitive to a view of institutional ontology based in communicative competence (Klein and Hirschheim, 1984; Lyytinen, 1985).

I can demonstrate the weaknesses of the conventional worldview based in the Bunge-Wand-Weber ontology by considering a simple problem in information modelling taken from the domain of medical emergency response, which I consider in more detail later. Suppose you are given the task of representing an emergency incident on an information model. The conventional worldview assumes that an emergency incident is an objective fact, much in the same way that the existence of an emergency ambulance vehicle is an objective fact. However, as the discussion in further sections shall show, the existence of an emergency incident is an institutional fact reliant on communication through speech acts.

Speech act theory was first developed in the work of Austin (1962) and expanded in the early work of Searle (1970) and colleagues (Searle and Vanderveken, 1985). The main idea is that engaging in some communication, such as uttering a sentence, is the performance of an act. Speech acts are acts of communication in which actors create and send messages in an appropriate context with certain intentions, normally to influence the action of the receiver of the message. Although these acts of communication are referred to as speech acts, such acts are not restricted to the use of spoken language and would also be taken to cover written texts and the use of other signs such as gestures, flags, records etc. Therefore, to avoid confusion, I prefer to use the more encompassing term *communicative act*.

There are many examples of communicative acts evident in the domain of medical emergency response. For instance, dispatchers are regularly instructing an ambulance driver to '*go to this location and attend this emergency incident*'. Sometimes this act will involve a radio message. Most often, it will involve an electronic message transmitted to an ambulance resource, received on some dashboard display and read by the ambulance driver. Or consider another example in which ambulance drivers are expected to assert to dispatchers when they have '*arrived at the allocated incident*'. This communicative act will consist of selecting an option on the ambulance's dashboard display, which transmits a signal back to the control incident system; that in turn updates the display of the dispatcher.

Any communicative act can be unpacked in terms of their locutionary, illocutionary and perlocutionary aspects. Austin (1962) would refer to the act of creating a message using some medium (such as sound waves or radio waves) as a locutionary act. Searle (1970) distinguishes between two aspects of such a locutionary act: the act of physically creating some form (an utterance act) and the act of using such form to refer to or describe something (a propositional act). For instance, the utterance associated with the message '*go to this location and attend this emergency incident*' consists of a radio signal transmitted to an ambulance resource and displayed on the dashboard display. The propositional act associated with the same message consists of some propositional content. In this case, incidents and locations refer to 'things' of significance, important to actors to reference and describe within communication about this institutional domain.

But the propositions of some communicative act not only have content, they have intent. In other words, actors create messages such as this to achieve some result. Searle (1975) develops a taxonomy of five different types of intent (or what Searle refers to as illocutionary force) that the actor performing a communication has, which he refers to as assertives, directives, commissives, expressives and declaratives. For instance, the communication '*go to this location and attend this emergency incident*' as an illocutionary act corresponds to a directive. Directives are communicative acts that represent the senders' attempt to get the receiver of a message to perform action.

Finally, perlocutionary acts refer to the effects or consequences that illocutionary acts have upon receivers of the message. The desired effect or conditions of satisfaction (Searle, 2000) for a directive is that by requesting that you do something you do it. Hence, the communicative act '*go to this location and attend this emergency incident*' is satisfied if the ambulance driver does as is requested.

Surprisingly, there are relatively few attempts to develop an approach to information modelling grounded in this language/action tradition. However, there are approaches which have attempted to engage with information modelling in a way more sensitive to a worldview based more generally in the idea of the communicative competence appropriate to some institutional domain.

'Natural language Information Analysis Method' (NIAM) was developed originally by Nijssen as a means of modelling the 'facts' relevant to a domain of discourse (Verheijen and Van Bekkum, 1982). NIAM used just two constructs to do this - entities and roles, which are used as a means of decomposing natural language statements held important within use by domain actors and representing them in a formal and visual notation. 'Object-Role Modelling' (ORM) (Halpin, 2008), is a development of NIAM, which conceives of a domain in terms of objects that play roles. Developing Ontology-Grounded Methods and Application (DOGMA), is an approach to information modelling which explicitly separates what it refers to as the language level from the conceptual level (Spyns, Meersman and Jarrar, 2002). The lexical representation of a term (lexon) at the language level is turned into a concept definition at the conceptual level through a close analysis of the context of term use.

NIAM, ORM and DOGMA all develop a set of constructs and notational representation significantly different from the conventional practice of information modelling. However, the conceptual grammars of NIAM, ORM and DOGMA use a representation much like binary relations. These approaches make no explicit use of language/action ideas such as speech acts, but all three approaches are sensitive to the notion of communicative context as the proper framing for information modelling. However, they are not explicit about how such communicative context is formed and how the modeller should approach an institutional domain in terms of such context. In contrast, I stick with the both the constructs and notational representation adopted for

information modelling as exemplified in the work of Chen (1976). I utilise binary relations merely as a canonical form for an information model and as a way of bridging between the communicative context relevant to some institutional domain and the visualisation of some information model.

Agerfalk and Eriksson (2004) use what they refer to as action diagrams to help develop the linkage between traditional information modelling and a language/action approach. Such action diagrams document the sequence of business actions performed within some process. Each business action is represented in terms of participating actors and information and material flows. The state changes to the domain are also tagged to each action. An information model is what they refer to as a static model, and they propose that building this should always occur after the analysis of the dynamic communicative action evident in the domain.

Despite its promise as a theory of language as completed acts of communication, the literature pertaining to speech act theory tends to unpack communicative acts as isolated events. In actual communicative practice, of course, individual communicative acts take place within wider 'conversations' and 'dialogues', frequently between multiple actors distributed across time and space. One of the key innovations of work within the language/action tradition was in developing ways of understanding and representing such distributed 'conversations for action' (Winograd and Flores, 1986) as networks of communicative acts. The other key innovation was in applying speech act theory to a bounded domain of language use. I follow this tradition and refer to a delimited conversation for action relevant to an institutional domain as a communicative pattern. I see the communicative pattern as the proper context for the development of an information model and I represent the narrative of a communicative pattern as a network using the artefact of a pattern comic.

Like Agerfalk and Eriksson (2004), I explicitly utilise constructs from the language/action tradition such as speech acts. But unlike the action diagrams proposed by these authors my pattern comics explicitly detail both the intent and content of communicative acts. I also represent the sequencing of such acts in a pattern, and do this to explicitly document the communicative context appropriate for an information model. Finally, like March and Allen (2014) I see much benefit in both the later as well as the early work of Searle. March and Allen provide a cogent critique of the tenets of conventional information modelling in terms of the social ontology of Searle. They also provide a series of steps by which a social ontology view can be used to guide the information modeller. In contrast, the primary goal of the current paper will be to describe a series of linked techniques which practically accomplish the creation of an information model sensitive to a social ontology worldview.

In the next section I introduce in more detail the domain of medical emergency response. This is used as a means of grounding my discussion of the innovative approach to information modelling

proposed. The section which follows demonstrates how the communicative pattern evident within this domain can be represented as a pattern comic.

Medical emergency response as an illustrative example

I choose to utilise the enacted domain of emergency response here as grounding for my exploration of information modelling for the following reasons. First, the domain of emergency ambulance command and control is one which is familiar and well-covered both in the Information Systems literature (Fitzgerald and Russo, 2005; Mcgrath, 2006) and in cognate literatures (Blandford and Wong, 2004). Second, although complex in practical action this domain is reasonably manageable for consideration within the context of a journal paper in that it involves relatively few actors performing routine action. My description of the pattern of communicative action constituting the domain of medical emergency response here is based upon previous case material developed by the author through interviews with and observation of two UK ambulance services (Beynon-Davies, 1995, 2013). The original description of ambulance command and control systems published in the 1990s (Beynon-Davies, 1995) has been significantly updated here using material sourced from these agencies (Beynon-Davies, 2013).

It is important to recognise that this case is not intended to provide empirical evidence, but merely to help ground aspects of my approach to information modelling. The domain is first described in written narrative. In further sections I unpack this case in terms of the approach proposed. To make connections between the different forms of representation easier, the life-cycle of an emergency incident is narrated as a series of numbered paragraphs below.

1. The life-cycle begins when telephone operators take an emergency call. The caller's area code or closest mobile phone cell is identified from the call, which is then routed to the ambulance control centre.
2. At the control centre a call-taker matches the call number with a physical address using a computerised map (or gazetteer) of the area covered by the service. The call-taker asks a pre-established series of questions of the caller(s), prompted by a set of rules embedded in the incident system.
3. Most ambulance services in the UK now institute a process of 'triage' to enable prioritisation of response to incidents. Calls are classified as category A (life-threatening), category B (serious but not life-threatening) or category C (does not require emergency response). On this basis, further decisions are made about the dispatch of resources to such incidents, taking account of two national targets set for response-times to category A and B calls. Within the UK, ambulance services are required to reach 75% of category A calls within 8 minutes and 95% of category B calls within 19 minutes (DOH, 2005). For category C calls, patients are referred to other health-care providers or transferred to a paramedic who will offer medical advice.

4. Assuming a call is categorised as either A or B, an emergency incident is declared and the location entered in an incident management system by the call-taker. A dispatcher will start to listen in to the call at this point.
5. The task of the dispatcher is to assess the most appropriate resource to send to the incident using a screen indicating a plan designed to maximise the efficient use of resources (known as the system status management or SSM plan), a screen listing the status of all resources and a screen which plots the current location of such resources against a computerised map. The SSM plan is an attempt to dynamically deploy resources around the area covered by an ambulance service according to demand patterns established for day and time, geographical area and clinical urgency.
6. Using this technology and her knowledge of the local area the dispatcher selects and assigns a resource to the emergency incident. The dispatcher uses a radio message to inform the crew about the location of the incident (including a map grid reference) and reported details of the patient's condition.
7. While the dispatcher is conducting this task the call-taker will be giving pre-arrival advice to the caller. In certain extreme cases the call-taker will remain in continuous communication with the caller until the ambulance arrives at incident.
8. Following receipt of an incident alert from the control room, and once mobile, a member of ambulance crew presses a button on their communication set to indicate departure. Crews are guided by satellite navigation to the incident location, supplemented with radio communication from the control room.
9. Upon arrival, a member of crew presses an *arrive* button on the communication set. A paramedic then administers any immediate treatment required at the scene and communicates the medical condition of the patient back to ambulance control.
10. The dispatcher will enter details of the patient condition and the treatment administered into the incident system. If the patient condition is sufficiently serious, the dispatcher will request of a general patient admissions system to suggest possible hospitals to admit the patient based upon the patient condition, the location of the incident and the location of hospitals. If the patient condition is deemed non-serious then the ambulance resource makes itself available for further allocation.
11. In the case of further treatment being required, the dispatcher will select an admitting hospital and communicate the patient condition and likely time of arrival to the emergency department of this hospital. The admitting hospital is indicated to the ambulance crew by the dispatcher. When the patient is deemed ready she is moved into the ambulance and prepared for departure. A crew member then presses a *leave scene* button.
12. Upon arrival at the general hospital, an *at hospital* button is pressed.
13. As soon as a cubicle is available in the emergency department, the patient is admitted.

14. Finally, the crew presses a *clear* button which declares that they are available to be allocated as a resource again.

The communicative pattern of medical emergency response

A pattern in general consists of a set of differences (Bateson, 1972) that repeat across situations. Hence, it is possible to discern a patterning of communicative action within the domain of emergency response, in the sense that multiple actors engage in ordered and repeating sequences of communicative acts. Abell (2004) believes narrative involves some attempt to represent the orderly arrangement of actors engaging in action in some temporal sequence. For example, within the life-cycle of an emergency incident the communication '*instruct resource*' typically occurs before a communication '*arrival at incident*', which in turn comes before assertion of patient condition and treatment at the scene.

The challenge is to come up with a convenient way of representing patterns of communicative action that can be understood not only by business analysts but also by actors within the domain in question. This is because the representation must act as a key sensemaking tool (Weick, 1995) within acts of co-creation. I have used pattern comics in previous work as a convenient, intermediate representation for building narratives of communicative action (Beynon-Davies, 2014).

Pattern comics consist of one or more comic panels which delimit the pattern in question. Each panel, in turn, contains one or more cells which are used to represent events within the pattern. Cells are joined together with dotted lines to indicate the temporal sequencing of action. In terms of a communicative pattern each cell consists of one or more communicative acts enacted by one or more actors. Solid arrows are drawn between actors within cells to indicate the direction of message transmission. A speech bubble is attached to the arrow and annotated with the intent expressed as a keyword (ASSERT, DIRECT, COMMIT, DECLARE, EXPRESS) and the content placed within square brackets. At certain points within the flow of communication decision points may change the trajectory of communication and are visualised as thought bubbles with internal directives. A comic of the communicative pattern relevant to the case of emergency response is illustrated in figure 1, and is based upon the written narrative provided. The numbers in each cell of the comic refer to the relevant paragraphs of the written narrative.

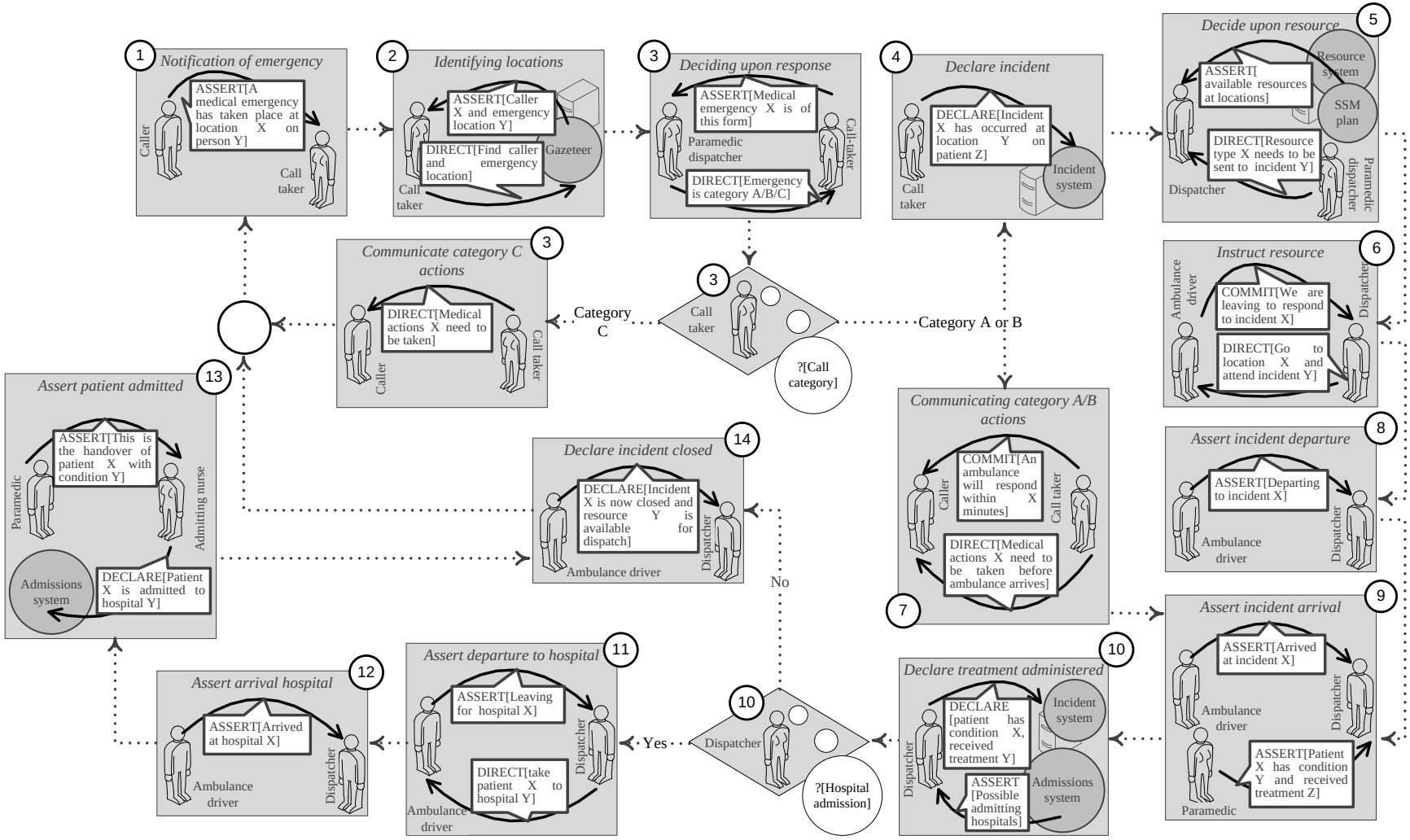


Figure 1. The communicative pattern for the domain of emergency response

The content of communicative acts

Much of Searle's theoretical edifice relies upon the distinction and relationship between brute facts and institutional facts. The primary difference between a brute fact and institutional fact relies upon the different status that such facts have in relation to some theory of existence – some ontology. Smith (2003) argues that this means that Searle is dealing with two levels of ontology. Facts on the 'lower' level exist independently of human beings and their institutions. Facts on the 'upper' level depend upon human institutions and on the exercise of collective intentionality (Searle, 1983), which is critical to institutionalisation.

Brute facts are so-called because they are matters of 'brute' physics, chemistry and biology. As such, brute facts are observer-independent. Within a brute fact the status of the thing (or things) referred to has an existence independent of institutions - even of the institution of language – although the expression of such facts relies upon the institution of language. In terms of medical emergency response, brute facts constitute the ontology of physical things such as human beings and their medical conditions, the physical configurations of ambulances and medical equipment as well as the topological layout of the area covered by the emergency service. Hence, it is a brute fact that an ambulance station can physically hold no more than 5 ambulances and that this ambulance station is situated 12.5 kilometres from its nearest general hospital.

In contrast, institutional facts are matters of culture and convention, and as such, are observer-relative. Within an institutional fact the status of the thing (or things) referred to depends upon a collective acceptance by the actors concerned that the thing has a certain function. This means that institutional facts exist only within the context of human institutions and are brought into existence through collective declaration of status functions by actors within such institutions. Institutional facts are important because they serve to constitute the institutional domain itself as a social ontology. Hence, the following institutional facts might be established within the communicative action evident in a response to an emergence incident:

- Ambulance resource 423 has been dispatched to incident 120453…
- Ambulance resource 423 consists of two crew members D46 and P54 and equipment 24346 and 32895…
- Crew member P54 is named Jane Bloggs and is a paramedic…

All these facts rely upon collective acceptance of the meaning of key terms utilised in utterances by actors such as *resource*, *incident*, *crew member* and *P54*. The meaning of such terms is not just a matter of reference and predication, but is constituted through the effects they have upon action.

In his first rendering of social ontology, Searle defined an institutional fact as a brute fact plus the collective assignment of a type of function – which Searle refers to as a status function. Humans within

institutional settings impose intentionality upon entities that are not intrinsically intentional through such status functions. For example, one particularly important 'thing' engaged with by the emergency ambulance service is the individual human being. The physical properties of this 'thing' are observer-independent. But certain of such things are assigned a status within the institution of medical emergency response. They become 'patients' of this institution, and become so because actors within this domain assign a particular institutional status to such things. In doing so, these individuals acquire certain rights and responsibilities associated with this assigned status. In more recent work, Searle makes a correction to this definition and acknowledges that status functions can be defined purely in terms of other status functions. This means that the component elements of some communicative content can refer to institutional 'things', such as emergency incidents, as well as physical 'things', such as individual persons.

For Searle (1995, 2006, 2010), status functions are achieved through application of what he refers to as constitutive rules. A constitutive rule takes the form *X counts as Y in C*, where X and Y are placeholders for significant patterns and C is a placeholder for the context in which the constitutive rule holds. Take the example of a constitutive rule relevant to the domain of medical emergency response, namely, *P54 is named Jane Bloggs*. Within this rule, X (P54 as an institutional identifier) counts as Y (a person named Jane Bloggs) in C (the communicative pattern of medical emergency response).

Using these ideas, I define an information model as a model of the declarations of significance relevant to some domain of communicative action. I go further and suggest that the patterning of communicative action within some domain forms the proper context for the constitutive rules which define status functions. A further consequence is that an information model is or should be an attempt to abstract from and represent the structure of communicative content critical to communicative action within the domain under investigation.

Forming classes, attributes and associations

Within his early publications, Searle (1970) argues that the terms making up the message within some act of communication fulfil one of two functions – they refer to or they predicate 'things'. The referring function enables communicative actors to identify a 'thing' while the predicating function serves to describe a 'thing'. I use the term thing here in an entirely neutral way to stand for anything that can be referred to or predicated by communicative actors (Searle uses the term 'object').

Referring is a critical function which allows the sender of some message to specify one and only one thing to which an utterance applies, while also providing the means for a receiver to identify the thing from the utterance. Searle (1970) maintains that language is used to refer in two major ways: either through use of an identifier or through some definite description. For instance, personal names such 'Jane Bloggs' are typical identifiers, while a definite description of this person might consist of the

phrase '*the woman with red hair and a pronounced limp*'. Identifiers are particularly useful in patterns of communicative action because they can refer to something without the need to describe it.

Eriksson and Agerfalk (2010) use a definition of an identifier in terms of a 'refers to' relation, which builds explicitly from the work of Searle (1970). For them, to be an identifier a term must refer to one and only one thing within one or more communicative contexts over time and through space. This implies that there should be a one-to-one correspondence between the identifier and what it refers to within some communicative context or contexts.

Hence, I might express the general form of a refers to relation as a binary relation:

[<Identifier> REFERS TO <Thing>]

The 'thing' referred to might be a physical thing, such as:

[<Personal name> REFERS TO <Human>]

Or an institutional thing, such as:

[<NHS No.> REFERS TO <Patient>]

The key difference between a class and an identifier is that an identifier relates to one and only one thing. A class, in contrast, relates to many possible but similar things. Classes are thus universal constructs or concepts, whereas an identifier refers to unique things covered by the class. Hence, the term emergency incident used within the communicative pattern in figure 1 is a term used to classify instances of event significant to actors within the domain of medical emergency response. Each specific instance is referred to in this case through use of a distinct identifier, an incident number.

As mentioned previously, one class is typically distinguished from another class in terms of its intension. Hence, a Patient class might be defined in terms of properties such as identifiers and attributes:

[Patient REFERENCE nhsNo]

[Patient HASA personal name]

[Patient HASA age]

[Patient HASA sex]

[Patient HASA dateOfBirth]

NhsNo is used as the appropriate institutional identifier in this communicative context, while *personal name* becomes predicative in this context. *Age*, *sex* and *dateOfBirth* also act as predicates of attribution.

Upon an information model attributes are normally distinguished from information classes in the sense that attributes can take values but classes cannot (Eriksson *et al*, 2013). Therefore, choosing to model something as an attribute rather than a class is a distinction dependent on the uses made of significant patterns within communicative action. For instance, when one states for the domain of emergency response that a patient has a name and an age the analyst is making sense of the properties that are critical to communicate about and more particularly to use to describe 'things' of interest within this domain.

But the intension of a class must also include the association with other information classes. Such relations of association upon an information model are free-ranging predicates meant to count as the co-occurrence between instances of one information class and that of another. Hence, I might declare upon an information model that *[Emergency incident OCCURS Location]* or *[Emergency incident INVOLVES Patient]*. These associations effectively act as constitutive rules which both constrain and resource communicative action in this domain.

Information modelling from communicative patterns

I see information modelling as an act of sensemaking (Weick, 2005) between the business analyst and domain actors, in which '*sensemaking is a way station on the road to a consensually constructed, coordinated system of action*' (Taylor and Van Every, 2000). In terms of information modelling, sensemaking begins with an understanding of context. This provides the rationale for modelling communicative acts and patterns using a pattern comic. The idea of sensemaking also implies that information modelling must be an act of co-creation between the information modeller and domain actors. In such terms, a pattern comic can be used as a central artefact for organising extended stretches of dialogue between analysts and organisational actors about the communicative situation as it is currently.

One way of building a communicative pattern is to observe and collect together a series of actual communicative practices within the domain under consideration. Hence, in the case of medical emergency response one might collect samples of emergency calls, dialogue within the control centre and communications between dispatchers and ambulance resources. Such communicative practice might then be analysed using one or more established approaches for dealing with extended stretches of conversation such as content analysis or discourse analysis. However, in line with the general way in which business analysts typically approach 'requirements elicitation' (Siau, 2003) I would normally expect a communicative pattern to be built from a series of extended and unstructured interviews or workshops with domain stakeholders.

Elicitation of whatever form is a way-station to making sense of the communicative situation under investigation in terms of a pattern comic. To do this we need some understanding of not only what is

communicated and by whom but the chronology of communication and how this relates to coordination of activity. The representation of communicative acts upon a pattern comic, as well as the chronology of such acts, is necessarily a narrative abstraction of the communicative situation. Each speech bubble placed upon a pattern comic is an abstraction of a range of actual communications we might find while investigating an ambulance control centre and its associated ambulance crews. Hence, the content - *a medical emergency has taken place at location X on person Y* – is an abstraction of utterances between callers and call-takers within ambulance control.

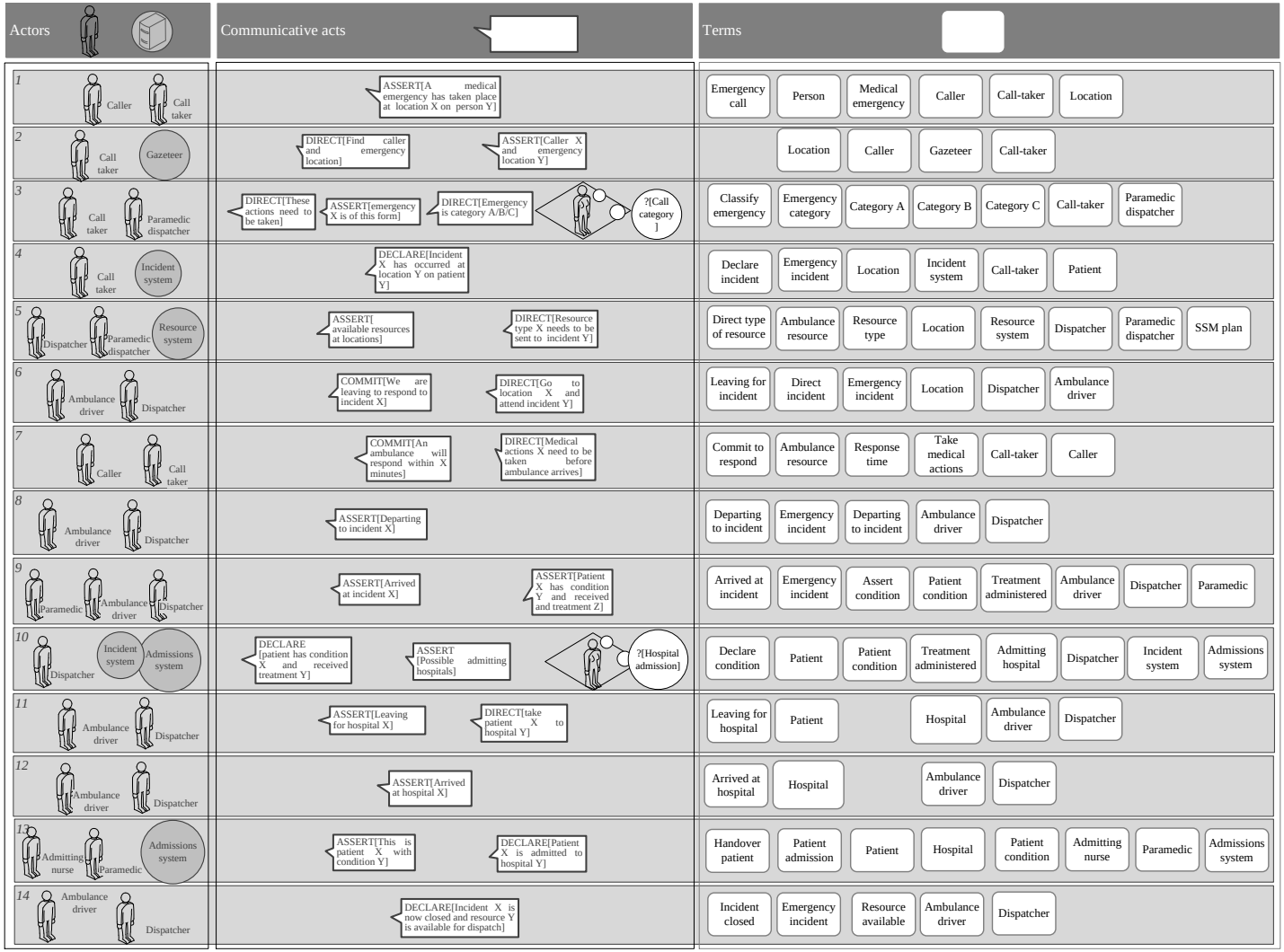
The next step is to collect together a complete set of terms used within and about the communicative acts represented upon a communicative pattern. Table 1 extracts such terms and presents them alongside the actors and acts in which such terms appear in figure 1. Most of the terms consist of things identified and described, such as, *emergency incident*, *patient*, *ambulance resource* and *location*. But the table also includes appropriate terms for communicative actors that participate in communicative acts - *dispatcher*, *caller*, *paramedic* and *incident system*. Finally, I need to include terms for certain critical communicative acts themselves that are likely to be referred to and described: *emergency call*, *arrived at incident* or *admit patient*.

To form binary relations, I need to make decisions as to whether the terms identified in table 1 are used to identify or describe things of interest in the communicative context under consideration. Most of the terms present within table 1 would serve to classify and thus to identify things of interest. Thus, I can infer the presence of institutional identifiers for classes such as:

[Patient REFERENCE nhsNo]

[Medical emergency REFERENCE emergencyNo]

Table 1. Actors, acts and terms within the communicative pattern of emergency response



Classifying terms also relate to terms which serve primarily to designate or describe. Hence, *patient condition* serves to describe the diagnosed medical condition of an identified patient, while *treatment administered* designates a course of medical intervention undertaken upon a patient. These are represented as relations of attribution, such as:

[Patient HASA medical condition]

[Patient HASA medical treatment]

Finally, I need to decide whether things referred to by classifying terms co-occur within the communicative pattern under consideration. When there is evidence of terms relating to other classifying terms, then I have instances of association. These are represented by free-ranging predicates, such as:

[Call-taker HANDLES Emergency call]

[Emergency call CALLED FROM Location]

[Emergency incident INVOLVES Patient]

This means that I make sense of the communicative pattern of medical emergency response in terms of the list of binary relations represented in table 2. Note that the terms forming classes, attributes and associations are defined here on first occurrence in the pattern and not repeated in the table.

Table 2. Binary relations pertinent to the terms in table 1

	Class	*Attribute*	*Association*
1	*[Emergency call REFERENCE callNo]*	*[Medical emergency HASA emergencyDescription]*	*[Caller MAKES Emergency call]*
	[Person REFERENCE name]	*[Person HASA personDescription]*	*[Call-taker HANDLES Emergency call]*
	[Medical emergency REFERENCE emergencyNo]	*[Caller HASA callerDescription]*	*[Emergency call ABOUT Medical emergency]*
	[Caller REFERENCE callerNo]	*[Call-taker HASA calltakerDescription]*	*[Person INVOLVED IN Medical emergency]*
	[Call-taker REFERENCE handlerID]		
2	*[Location REFERENCE locationID]*	*[Location HASA locationDescription]*	*[Emergency call CALLED FROM Location]*
	[Gazeteer REFERENCE versionID]	*[Location HASA coordinate X]*	*[Medical emergency OCCURS AT Location]*
		[Location HASA coordinate Y]	*[Location IDENTIFIED IN Gazeteer]*
3	*[Paramedic dispatcher REFERENCE practitionerID]*	*[Medical emergency HASA emergencyCategory]*	*[Paramedic dispatcher CLASSIFY EMERGENCY Medical emergency]*
	[Category C response REFERENCE responseID]	*[Classify emergency HASA eventDateTime]*	*[Medical emergency BECOMES Category C response]*
	[Classify emergency REFERENCE eventID]	*[Take medical action HASA eventDateTime]*	*[Medical emergency BECOMES Emergency Incident]*
	[Take medical action REFERENCE eventID]		*[Call-taker ISSUES Category C response]*
			[Call-taker TAKE MEDICAL ACTION Caller]
4	*[Emergency incident REFERENCE incidentID]*	*[Patient HASA DateOfBirth]*	*[Emergency incident OCCURS AT Location]*
	[Incident system REFERENCE versionID]	*[Patient HASA Name]*	*[Call taker DECLARE INCIDENT Emergency incident]*
	[Patient REFERENCE nhsNo]	*[Patient HASA Sex]*	*[Emergency incident INVOLVES Patient]*
	[Declare incident REFERENCE *eventID]*	*[Declare incident HASA eventDateTime]*	*[Person BECOMES Patient]*
		[Emergency incident HASA startTime]	*[Emergency incident RECORDED IN Incident system]*
5	*[Ambulance resource REFERENCE resourceID]*	*[Ambulance resource HASA resourceType]*	*[Ambulance resource CURRENTLY AT Location]*
	[Resource system REFERENCE versionID]	*[Direct resource HASA eventDateTime]*	*[Paramedic dispatcher DIRECT RESOURCE Ambulance resource]*
	[SSM plan REFERENCE versionID]	*[Availability HASA eventDateTime]*	*[Resource system AVAILABILITY Ambulance resource]*
	[Direct resource REFERENCE *eventID]*		*[Ambulance resource SSM PLAN Location]*
	[Availability REFERENCE *eventID]*		
6	*[Dispatcher REFERENCE dispatcherID]*	*[Leaving for incident HASA eventDateTime]*	*[Ambulance driver LEAVING FOR INCIDENT Dispatcher]*
	[Ambulance driver REFERENCE driverID]	*[Direct incident HASA eventDateTime]*	*[Dispatcher DIRECT INCIDENT Ambulance driver]*
	[Leaving for incident REFERENCE *eventID]*		
	[Direct incident REFERENCE *eventID]*		

7	*[Commit to respond* REFERENCE *eventID]*	*[Commit to respond HASA responseTime]*	*[Call-taker COMMIT TO RESPOND Caller]*
		[Commit to respond HASA eventDateTime]	
8	*[Departing to incident* REFERENCE *eventID]*	*[Departing to incident HASA eventDateTime]*	*[Ambulance driver DEPARTING TO INCIDENT Dispatcher]*
9	*[Arrived at incident* REFERENCE *eventID]*	*[Arrived at incident HASA eventDateTime]*	*[Ambulance driver ARRIVED AT INCIDENT Dispatcher]*
	[Assert condition and treatment REFERENCE *eventID]*	*[Assert condition and treatment HASA eventDateTime]*	*[Paramedic dispatcher ASSERT CONDITION AND TREATMENT Dispatcher]*
10	*[Hospital REFERENCE hospitalID]*	*[Patient HASA patientCondition]*	*[Dispatcher DECLARE CONDITION AND TREATMENT Incident system]*
	[Declare condition and treatment REFERENCE *eventID]*	*[Patient HASA treatmentAdministered]*	*[Emergency incident RECORDED IN Incident system]*
		[Declare condition and treatment HASA eventDateTime]	
11	*[Leaving for hospital* REFERENCE *eventID]*	*[Leaving for hospital HASA eventDateTime]*	*[Ambulance driver LEAVING FOR HOSPITAL Dispatcher]*
	[Direct hospital REFERENCE *eventID]*	*[Direct hospital HASA eventDateTime]*	*[Dispatcher DIRECT HOSPITAL Ambulance driver]*
12	*[Arrived at hospital* REFERENCE *eventID]*	*[Arrived at hospital HASA eventDateTime]*	*[Ambulance driver ARRIVED AT HOSPITAL Dispatcher]*
13	*[Admitting nurse REFERENCE nurseID]*	*[Patient handover HASA eventDateTime]*	*[Paramedic PATIENT HANDOVER Admitting nurse]*
	[Patient handover REFERENCE *eventID]*	*[Patient admission HASA eventDateTime]*	*[Admitting nurse WORKS AT Hospital]*
	[Patient admission REFERENCE *eventID]*		*[Admitting nurse PATIENT ADMISSION Patient]*
			[Hospital PATIENT ADMISSION Patient]
			[Patient admission RECORDED IN Admissions system]
14	*[Incident closed* REFERENCE *eventID]*	*[Incident closed HASA eventDateTime]*	*[Ambulance driver INCIDENT CLOSED Dispatcher]*
	[Resource available REFERENCE *eventID]*	*[Resource available HASA eventDateTime]*	*[Dispatcher RESOURCE AVAILABLE Availability]*

A visualisation, such as that illustrated in figure 2, can then be produced by drawing classes and applying the necessary associations directly from table 2 (attributes have been left off this visualisation, purely because of space limitations). Appropriate cardinality and optionality for each association will need to be derived from closer questioning with domain actors.

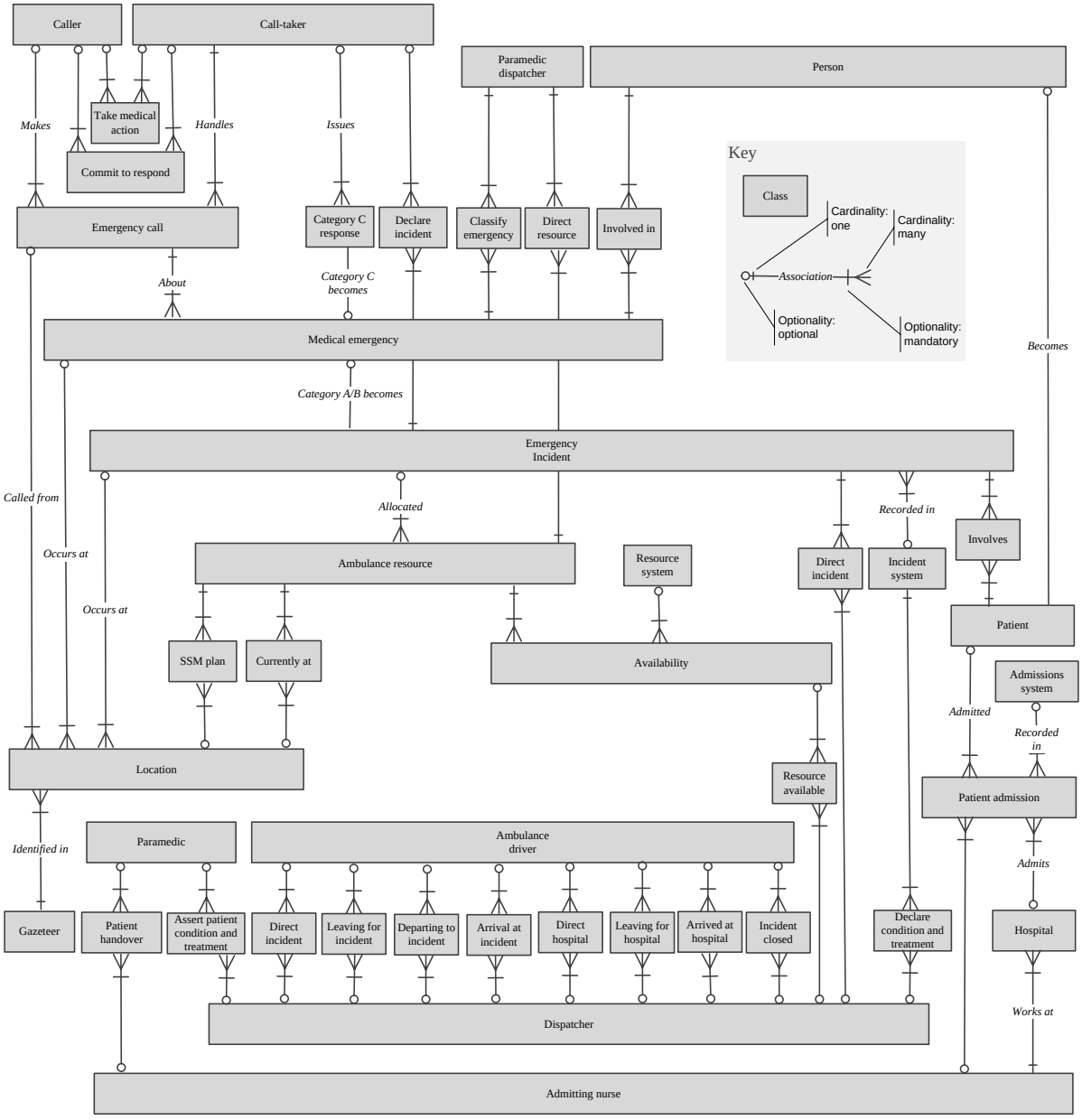


Figure 2. An information model for the domain of emergency response (derived from table 2)

It is important to re-confirm the validity of an information model with domain actors, because the 'quality' of any information model can only be established through acts of sense-making. In other words, rather than thinking of an information model in terms of 'accuracy' or 'consistency' I need to ask - does my representation do justice to the patterns of communicative action in the domain? In this

sense, an information model is necessarily a pragmatic construct – it focuses upon and is always oriented towards action.

Discussion

In previous sections I have explored the pragmatics of information models using a delimited institutional domain to ground this exploration. My main aim in doing this was to demonstrate that the elements of an information model are necessarily semiotic and pragmatic constructs. They are signs used by actors within some communicative pattern to declare institutional facts, which serve to facilitate the coordination of instrumental action. In the current section, I wish to discuss some of the pragmatic consequences of this alternative view of information models. In other words, what difference does this change of worldview make to the actions of both modellers and institutional actors?

I began this paper by highlighting that to practice information modelling successfully requires two forms of knowledge: modelling knowledge and domain knowledge. Modelling knowledge refers to a set of principles and skills associated with the application of the modelling approach. Domain knowledge refers to understanding the area of application – the institutional domain. Hay's (1996) notion of an 'organisation's nature' is for me a matter of institutional ontology. I have demonstrated how many of the breakdowns experienced in applying information modelling in practice result from ontological assumptions that underlie the conventional worldview associated with information modelling. Traditionally, and as established in previous literature (Wand and Weber, 1990; Wand and Weber, 1995), an information model is portrayed as an unchallenged and unequivocal representation of some organisational area: a declaration of brute facts about some institutional domain.

Through the lens of social ontology, the term ontology (Shanks, Tansley and Weber, 2003) is more accurately conceived of as the institutional context within which status functions are used by a group of actors to constitute things of interest through the application of constitutive rules, and through such constitution to declare institutional facts. In this sense, the declaration of institutional facts as well as the status functions from which they are constructed create or re-create the domain of discourse which they represent.

This account of the nature of information modelling helps explain problems experienced in using information modelling in practice. When trying to information model it is typically difficult to know where to start and what constructs to use. In other words, what things are or should be of interest and what constructs should be used to model such things? Take the attempt to represent *marriage* upon some information model. Following from the approach to information modelling suggested in this paper, the answer to modelling *marriage* upon an information model depends upon the communicative context within which this status function is used. For the domain of medical emergency response, marriage is probably only important as a means of signalling to control, ambulance and hospital staff

that there is an important next of kin to communicate with. Hence, modelling marriage as a descriptive term – as an attribute (marital status) of a patient - might be sufficient for the patterns of enactment evident in this domain. For some tax authority, marriage is of interest because it may affect the tax position of certain citizens – hence, it is probably appropriate to model this situation as an association, perhaps a recursive association with a citizen class. Finally, for a marriage registry the event of marriage itself is the significant thing of interest. Hence, it is appropriate to represent marriage within this institutional context as a class, with its own attributes and associations.

At first glance, the information model illustrated in figure 2 may appear over-complex, because it attempts to encapsulate all, not part of, the communicative context illustrated in figure 1. The classes and associations on such an information model might appear to represent undisputed things of interest for actors within this domain. In practice, classes such as *patient*, *medical emergency* and *emergency incident* act as status functions which help 'scaffold' (Orlikowski, 2006) this institutional order. What constitutes or should constitute a patient and what constitutes a true emergency and thus a valid emergency incident is a continuous source of sensemaking for participating actors within the domain of medical emergency response. An emergency call only becomes a medical emergency and consequently an emergency incident through the ways in which actors such as paramedic dispatchers triage events. An emergency call only becomes the institutional fact of an emergency incident if it is deemed sufficiently 'serious' to warrant dispatch of an ambulance.

I would suggest that an information model, such as the one in figure 2, also has certain advantages in term of flexibility (Fitzgerald, 2000) to accommodate change to institutional action. For example, in 2005 the UK government (Wankhade, 2011) recommended that targets set for responding to emergency calls should be measured consistently across the UK. It suggested that the clock should start ticking when an emergency call is connected to the control centre and not when the call-taker declared an emergency incident; which is what most UK ambulance services had been measuring. Following adoption of this subtle recommendation, UK ambulance services have spent years re-configuring their IT systems; because on average the difference between connecting a call and identifying an incident is as much as one minute. The information model in figure 2 distinguishes between an emergency call and an emergency incident and thus could easily accommodate this change to the measurement of performance. Indeed, as suggested in table 2 the information model has the potential to log every critical state communicated about within the life-cycle of an incident.

More interestingly, statistics collected on the practice of emergency response reveal that while 30% of calls are categorised as life-threatening by call-takers and ambulance-dispatchers only 10% of such incidents turn out to be life-threatening in nature. Also, 77% of all emergency calls result in a journey to a local hospital but only 40% of these patients are eventually admitted for treatment (DOH, 2005). There are complex reasons for this situation. Nevertheless, various ambulance units have attempted to

make changes to such breakdowns in practice, to meet the implicit intentions expressed in such measurement. For instance, some have begun to reconfigure their IT systems to collect a patient summary containing not only important medical data about the patient but also a history of interaction with the ambulance service. This inherently amounts to a re-configuration of the notion of what *patient* and *incident* means to emergency response. It is hoped that records based upon such reconfiguration will not only allow call-takers to refine the process of triaging patients and incidents but also better signal to an ambulance crew what to expect at incidents and consequently how better to perform. It should be evident on the information model in figure 2 that a clear distinction is drawn between a person described within the context of an emergency call and an eventual patient responded to. This might enable a more nuanced history of interaction with a service, which might better inform changes to practice.

Conclusion

This paper makes the following contributions to the literature. First, I have articulated features of the continuing juncture between information modelling in theory and information modelling in practice. Second, I have shown how problems experienced in the application of information modelling are due in large part to an inappropriate ontological basis for information modelling. Third, I have demonstrated how an alternative worldview provided by the language/action tradition provides a more satisfactory ontological foundation for information modelling based in the notion of the communicative competence held significant within some delimited institutional domain. Fourth, I have demonstrated how Searle's recent work provides a way of positioning such communicative competence as a 'bridge' between physical and institutional ontology. Fifth, I developed an appropriate theorisation of the constructs of an information model which is consistent both with a language/action worldview and with Searle's notion of social ontology. Sixth, I have suggested a practical approach to doing information modelling which is compatible with this theorisation. Finally, I have demonstrated that this approach has important pragmatic consequences: providing a way of avoiding many of the problems experienced with information modelling in practice; constructing information models which are much more robust and flexible within institutional action.

There are many potential avenues of further work that arise from the approach suggested in this paper. For example, the theorisation proposed is deliberately limited in scope currently and does not do full justice to certain developments within the philosophy of language that have a direct bearing upon information modelling. Derrida (1971) has criticised Austin's original idea of an illocutionary act. He argues that any speech event is framed by a 'structure of absence' (the words that are left unsaid due to contextual constraints) and by 'iterability' (the constraints on what can be said, given by what is said in the past). Hence, and as I briefly alluded to within the paper, the ways in which institutional facts are created is not only a matter of ontology, it is also a matter of deontology. Searle, himself, has

acknowledged in his recent work that the status in his functions carry with them not only ontological assumptions but also assumptions about both positive power (rights, permissions, authorisations etc.) and negative power (obligations, duties, responsibilities) (Searle, 2005). My approach needs ways of handling the practices by which institutions constrain or enable action through the exercise of certain status functions more explicitly (Bergholtz, Eriksson and Johannesson, 2013; March and Allen, 2014).

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