Chapter 2
Unbounded Technology

Classifications as *Boundary Objects* provide a means for analysing the subtle interactions between communities of practice and technologies. This chapter uses the concept of boundary objects in order to analyse specific hazards, namely, *Boundary Hazards*, which expose organisations to system vulnerabilities. This chapter reviews different case studies. It highlights boundary objects and their mechanisms with respect to communities of practice and technological systems. Lack of understanding of boundary objects and failure to take subtle processes and interaction mechanisms into account in designing and deploying new technology represent potential hazards for technological systems. Technologies expose organisations to hazards across their boundaries. Analysing technological risk then requires an understanding of how hazards spread through organisational boundaries. It is necessary to deal with '*unbounded* technologies. The analysis enhances our ability to understand boundary objects in technological systems and their related risk.

2.1 Classification Systems and Boundary Objects

Classification systems, or simply *classifications*, provide a socio-technical viewpoint in order to analyse technological systems [8]. Classifications, such as information systems or infrastructures, are ubiquitous and pervasive in many professional and application domains. They shape and slice our societies, that is, they provide a means for categorising and gathering information[1] that constitutes *knowledge* in our *modern state* [7] or *risk society* [5]. On the one hand, classifications represent practical tools used in different application domains. On the other hand, classifications capture information flows in systems as well as organisations. For instance, the *International Classification of Diseases* (ICD) emerged as a means for monitoring and analysing diseases and their developments [7, 8, 33].

[1] The urge for statistical evidence or knowledge underpins the "modern state" [7] as well as the "risk society" [5], even though they are related accounts of the developments of the modern information society.

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The *International Classification of Diseases* (ICD), adopted and maintained by the *World Health Organization* (WHO), is part of the *WHO Family of International Classifications*, which provides practical tools for classifying diseases, monitoring their spread over populations, decision making and policy outlining (e.g. identifying contingency measures for isolating diseases) [31, 33]. The history of the ICD spans over the last four centuries, from the initial attempts to classify diseases systematically in the eighteenth century to the current tenth revision of the ICD (ICD-10) in the twenty-first century [33]. The first internationally adopted classification was the *International List of Causes of Death*. The changing name over the years captures the shift of the rationale and usage of the classification itself. The history of the ICD highlights a strong relational coupling with the developments of information technologies [7]. The future development of the ICD, i.e. the update to the ICD-11, is driven to some extent by technology too [30, 32]. There is the necessity to address the "information paradox" the patchy and uneven distribution of knowledge that stresses the disparities among countries. The most vulnerable and affected countries are the ones who would benefit most from the implementation of the ICD. Unfortunately, the dividend or lack of technology, as well as financial resources, exacerbates the gaps among countries. Technology innovation plays a critical role in addressing the WHO strategies and supporting its assets. For instance, the concept of e-health is central in the future development of the ICD. The health record intends to link terminologies to classifications in order to enrich the knowledge (i.e. enabling ontology-based terminology systems) and sustain the WHO knowledge network. Moreover, the identification of specific technology, such as the Extensible Markup Language (XML), would drive to some extent future implementation of the ICD and support other functionalities. A practical need is to improve the accessibility and implementation of the ICD by providing, for instance, a *Short Mortality List* (SML) in order to address the information paradox. The history of the ICD shows dependencies between the development of the classification and technology [7]. The better our understanding of their inter-dependencies, the better our ability to design technology systems that rely on classifications.

The classification of *faults*, *errors* and *failures* [4], for instance, enables causal analysis [19] in order to investigate and to assess (system) failures from a system viewpoint [18]. The identification of system vulnerabilities allows us to classify and assess technical risks [23]. However, the understanding of faults, errors and failures depends on cultural aspects peculiar to the application domain (specifying their definitions or meanings). Classification systems, therefore, are tightly coupled with their origin domains and their culture. They are the result of technical as well as socio-political struggles addressed over the years. Another example is the *ACM Computing Classification System*, which resulted from emerging subjects in computing [9]. However, it is possible to figure out that the (sub)classifications of some subjects have echoed the political arguments between different scientific communities. Universities' structures and degrees stress different understandings of scientific and research subjects, which often account for different communities and their socio-political arguments. The socio-political debate over technical arguments depends on the communities involved, their organisational structures, policies and perceptions (of risk) [14]. This debate is still continuing over the shaping of emergent multi- or inter-disciplinarities [28].

Technically, classifications represent (partially) ordered systems consisting of categories, which provide us with "a spatial, temporal or spatio-temporal segmentation of the world" [8]. *Standards* relate to classifications, but differ in the way they are imposed sometimes, resistant to change and adopted by different communities of practice [8]. Communities of practice characterise (or recognise) themselves by adopting or sharing different classifications or standards. Therefore, resulting classifications depend on the mechanisms of shaping them and the policies characterising communities. As risk is a social and collective construct [14], so classifications are too. Classifications, as well as standards, emerge from the negotiation of different communities of practice. They allow information to be spread across organisational boundaries. Classifications, and standards, reside in the intersection between communities of practice. They are *Boundary Objects*, which present those characteristics that allow them to be ubiquitous and pervasive in communities of practice [8]:

> Boundary objects are those objects that both inhabit several communities of practice and satisfy the information requirements of each of them. Boundary objects are thus both plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites. They are weakly structured in common use and become strongly structured in individual-site use. These objects may be abstract or concrete.

The intersection of different communities of practice, therefore, identifies *Boundary Objects*. Communities of practice recognise shared boundary objects, which capture trade offs between *generality* and *locality*. On the one hand, they capture *explicit knowledge* [29] as generally recognised by communities of practice. On the other hand, they also require *procedural knowledge* [29] in order to make boundary objects effective and available into specific localised situations. Communities of practice tailor them in order to satisfy local requirements. Therefore, boundary objects emerge over time due to *naturalisation* (e.g. cooperation and negotiation) by different communities of practice [8]. The adoption of boundary objects involves the process of naturalisation of the object within communities of practice. Whereas, *membership* to a community of practice requires the recognition of boundary objects as work practices [8]. Similar processes characterise *organisational memory* [1, 2]. Boundary objects require processes of "decontextualisation" and "recontextualisation" that enable organisational memories. Therefore, boundary objects, if suitable processes are in place, are enabling technologies for organisational memories. Boundary objects, as well as technology artefacts, fall short of enabling organisational memory without suitable processes supporting communities of practice. Characterising spatio-temporal dynamics of a classification involves reconstructing its trajectory. *Trajectories* capture the relationships, i.e. membership and naturalisation, between boundary objects and communities of practice [8].

Trajectories characterise the negotiation and shaping of boundary objects between different communities of practice. The negotiation of boundary objects, for instance, the negotiation of different classifications, identifies trajectories as being spatio-temporal ordered representational states [2, 8]. The negotiation process (between communities of practice) needs to address conflicts (e.g. belonging to different categories) arising among different classifications.

The *coupling* between boundary objects and communities of practice depends on the naturalisation of boundary objects within the community of practice as well as of the membership of communities of practice with respect to boundary objects. These relationships create subtle mechanisms of interactions between boundary objects and communities of practice (and themselves, respectively). Boundary objects are pervasive and ubiquitous in communities of practice sharing them. On the one hand, they identify communities of practice. On the other hand, communities of practice identify themselves with boundary objects. Collections of boundary objects and their relationships with communities of practice create *complex* networks of boundary objects, called, *Boundary Infrastructures* [8]. Coupling and complexity of technical systems provide a framework for the characterisation of risk [24]. Similarly, the tight coupling between boundary objects and communities of practice and the complexity of boundary infrastructures emphasise how organisational boundaries represent a hazard or source of risk for technological systems. As structures emerge in technical systems, boundary objects of communities of practice harden the coupling and complexity of such systems. Understanding these structures and the underlying mechanisms that let them emerge highlights boundary objects as enabling technologies for dependability [22]. A review of different case studies allows us to highlight boundary objects and their mechanisms with respect to communities of practice and technological systems. Lack of understanding of boundary objects and failure to take subtle processes and interaction mechanisms into account in designing and deploying new technology represent potential hazards for technological systems. The analysis enhances our ability to understand boundary objects in technological systems and their related risk.

2.2 Patterns of Boundary Infrastructures

Communities of practice tailor classifications, as well as standards, to their knowledge by membership and adopt them by naturalisation. Membership is a complex process of shaping boundary objects. Naturalisation of tools (e.g. classifications) and procedures (e.g. code of practice) is a process of adopting and recognising boundary objects as used within communities of practice. Hence, membership and naturalisation represent two relationships between boundary objects and communities of practices. Membership, on the one hand, from communities of practice to boundary objects, represents procedural knowledge, that is, the process of shaping

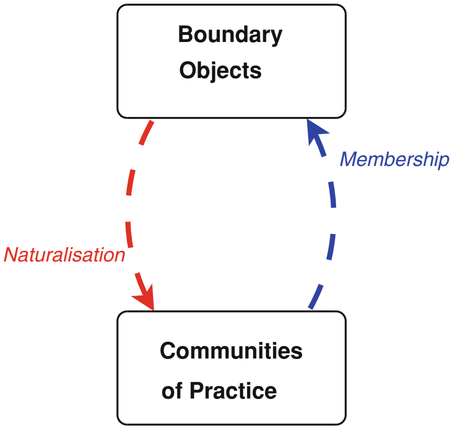

Fig. 2.1 Relationships between boundary objects and communities of practice

boundary objects by knowledge (e.g. descriptive knowledge) becoming available within communities of practice. Membership identifies boundary objects relevant to communities of practice. Once, for instance, engineering knowledge becomes available due to past experience (e.g. previous design or system failures), communities of practice select and share knowledge to be integrated into boundary objects (e.g. design methodologies and code of practice) [25, 26, 29]. Communities of practice then shape boundary objects by adopting and recognising new available knowledge. On the contrary, naturalisation, from boundary objects to communities of practice, captures the acquisition of general knowledge, embedded into boundary objects, as well as its contextualisation within communities of practice. Naturalisation consists of that process, from boundary objects to communities of practice, which characterises the adoption of boundary objects by communities of practice. The more communities of practice identify themselves with boundary objects, the more boundary objects became natural and pervasive in their usage. In other words, the adoption of boundary objects makes them natural (or non-intrusive) within communities of practice, who identify themselves with boundary objects. It is necessary to familiarise, acquire and use those characterising boundary objects in order to become a member of a community of practice. Figure 2.1 shows the two relationships as directed functions.

Boundary objects, therefore, capture knowledge distribution and coordination processes. They allow us to structure the analysis of organisational knowledge and the identification of related hazards. The investigation of technology innovation with respect to boundary objects identifies a class of technological hazards related to boundary objects, hence, *Boundary Hazards*. Our review of relevant case studies provides examples of Boundary Hazards and their identification.

Fig. 2.2 Mirrored organisations in terms of boundary objects and communities of practice

2.2.1 Standardisation

Organisational strategies often adopt standards and standardisation processes in order to achieve an increased level of control, hence predictability, over production processes and product features. The analysis of a transfer of knowledge between production sites highlights contingencies undermining the effectiveness of standardisation as organisational strategy [16]. One of the case studies in [16] reports the transfer of production processes between two manufacturing sites in the computing sectors. In order to increase its capabilities, a computer organisation acquired a production company, which was also critical for its know-how. It was initially considered the source of the transfer of knowledge because of its high-quality products. Although the two sites, i.e. the computer organisation and the production company, were located in different countries, the overall objective of the acquisition was to increase productivity as well as product quality.

The initial organisational strategy was to replicate standard production processes. This standardisation of production processes was perceived as a successful transfer of knowledge. The basic idea was to have two replicated processes strongly coordinated and coupled together. The production processes were replicated in order to transfer know-how from one site to the other. This would have enabled the two manufacturing sites to maintain, on the one hand, control over the production processes, on the other hand, predictable product reliability. The underlying assumption, later proved to be misplaced, was that highly standardised processes were strongly related to product quality characteristics (e.g. reliability), hence, they could have enabled the delivery of quality product. The initial standardisation strategy intended to reduce diversity between the two manufacturing sites by creating strong correspondences between them. This would have enabled the organisation to deliver products of predictable quality regardless of the production site. However, this proved problematic and gave rise to several issues. Figure 2.2 shows the relationships between the production sites in terms of boundary objects.

Process standardisation was imposed over the communities of practice. There was correspondence, in terms of adopted production artefacts and processes, between the two manufacturing sites. This relationship was obtained and forced by replicating production processes as well as organisational structures. It intended to maintain mutual-correspondences between contextualised knowledge, or boundary objects. Both sites, in terms of boundary objects, adopted the same organisational artefacts and procedures. These boundary objects supposedly provided and maintained coordination between the two sites, although local work practices differed.

The overall goal was to reduce organisational diversity, although the outcome was the opposite. The standardisation process imposed over the two sites emphasised cultural differences between them. Despite the coordination between the two sites, the reflection strategy emphasised differences between the two sites resulting in increased diversity. On the one hand, one production site, the originator, had a strong culture of personal commitment, which allowed a flexible production process with work-around strategies for tackling issues and unforeseen events. This flexible work organisation perceived the other site, the recipient, as over-bureaucratic with its commitment to standardised processes. On the other hand, the recipient organisation perceived few standardised processes, relying on uncodified work practices, as a hazard and potential source of undependabilities. The reflection strategy between the two sites resulted in *mistrust* between the two organisations. The two sites (in particular, the recipient organisation) perceived a *lack of trust*. Hence, they interpreted, the increased control and reduced flexibility were introduced in order to monitor their production activities, respectively. As a consequence of the striking differences, the two production sites requested many changes in order to adapt the standardised process to their local needs. Although the overall process was similar, local work practices were different. These changes and adaptations exposed the alignment of the two sites to increased diversity.

System diversity is, in general, related to properties of *robustness* and *fault tolerance* [20]. Diversity is in principle a 'good' property to have. Unfortunately, extending diversity to other system abstractions (e.g. diversity in safety or dependability cases [6, 21], diversity in organisations) or units of analysis presents some contingencies with respect to dependability. Controversially, diversity might expose organisations to subtle socio-technical hazards.

The overall objectives of the standardisation strategy considered this increased diversity between the two sites to be a failure of the transfer of knowledge. Moreover, due to the instability and unpredictability during the standardisation process, the organisation stopped any project aimed at product or process improvement. Questions, therefore, arise on reflection strategies and diversity with respect to organisations: *How does diversity relate to organisations? How does diversity expose organisations to hazards across organisational boundaries?*

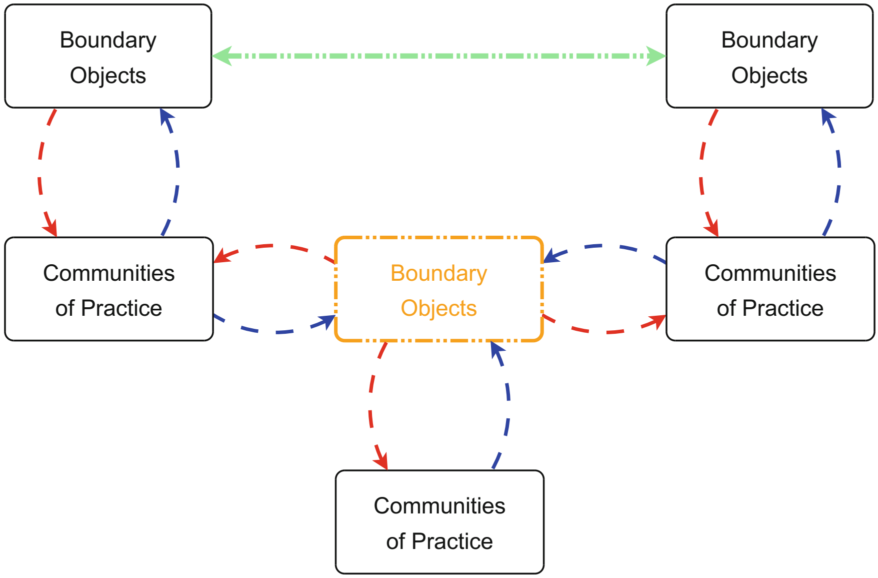

Fig. 2.3 Enhanced standardisation process

2.2.1.1 Restructuring Boundary Infrastructures

The organisation, in order to address the issues arising with the transfer of knowledge, implemented an overall process for controlling and monitoring the replication and contextualisation of the production processes in the two sites, respectively. A joint committee was established for the supervision and coordination of the standardisation process. The committee was responsible for the "exception approval process". This process implemented a change management policy and process dealing with all requests for changes now needing formal approval by the committee. Besides the change management process, the committee identified a set of rules in order to create a shared common understanding of work practices between the two sites. The restructuring introduced shared boundary objects (i.e. change management policies and processes) among common work practices. The implementation of these mitigation actions changed the overall organisation (i.e. structure) of the transfer of knowledge. Figure 2.3 shows the restructuring, in terms of boundary objects, of the organisational transfer of knowledge.

The standardisation process required additional change management policies and processes in order to increase the level of control over local adaptations and understand organisational diversities. The two sites, together with the joint committee, shared the new change management policies and processes with respect to local changes. This allowed the organisation to mitigate issues arising from standardisation. This increased control and understanding over the production sites, although it was initially perceived as a means of controlling and assessing performances of the recipient site. The perception was of lack of trust on local work practices. In a competitive effort, the recipient site exploited the reporting process as a means to gain control over the changes imposed to their work practices. This inhibited any process and product improvement during the transfer of knowledge.

2.2.2 Adopting Generic Technology

Another organisational strategy, often adopted, is the one of introducing and deploying generic technology, for instance, consisting of *Commercial-Off-The-Shelf* (COTS) products. The rationale behind a COTS strategy varies from the goal of reducing labour cost by automation to increasing the level of standardisation in work practices, coordinating different units or divisions of labour, capturing organisational knowledge into technology and so forth. This strategy seems often the most cost-effective and suitable solution, although it presents many pitfalls that may jeopardise any successful deployment as well as organisational effectiveness. Moreover, organisations often adopt generic technology, which misleadingly advocates 'innovation' of production processes with the introduction of new technology. A study in [16] of the introduction of generic technology highlights how the strategy of delegating organisational knowledge to software systems [11–13] may affect communities of practice [10], hence, work practices. Another study in [16] reports on the adoption of general technology in order to standardise work practices within a manufacturing organisation in the automotive domain. The overall objective was to integrate different communities of practice by the introduction of a generic COTS system, i.e. *Product Data Manager* (PDM) software. This would have enabled the technological innovation of organisational production processes and information infrastructures. The organisation, initially, relied on different artefacts, or boundary objects, capturing local knowledge and work practices. The production engineering workflow consisted of subsequent phases capturing organisational procedures [11, 12]. The production process, therefore, involved different boundary objects capturing diverse organisational knowledge. In other words, boundary objects enabled the production process as organisational knowledge or memory [1, 2].

Boundary objects, in order to support organisational memory effectively, need to be flexible general artefacts [8]. The process of *decontextualisation* allows boundary objects to enable organisational memory. Boundary objects capture explicit organisational knowledge [29] and make it available for reuse [1, 2]. Vice versa, the process of *recontextualisation* allows boundary objects to enable organisational memory in use [1, 2]. Procedural knowledge [29] enriches boundary objects and make them available to communities of practice. These processes also take place in the introduction of software technology in order to capture organisational memory. Software technology influences both *organisational declarative memory* and *organisational procedural memory* [12].

Therefore, the adoption of general (software) technology in order to capture organisational knowledge has several implications for the organisation too. The charac-

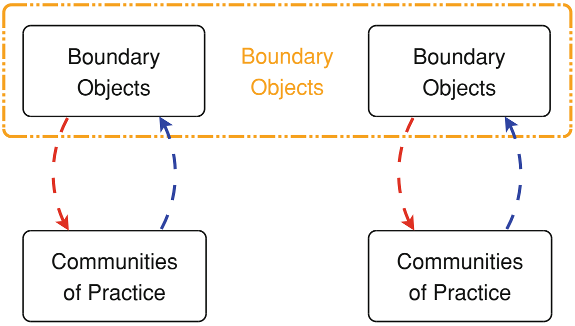

Fig. 2.4 Disruptive integration of different boundary objects

terisation in terms of boundary objects points out organisational memory, on the one hand, as an artefact having distinct identity and status, on the other hand, as a process exploiting specific expertise and knowledge. Production involved the translation and coordination from one artefact to the next one in the process. This was time-consuming and error-prone due to the manual and localised translation and coordination work involved. However, the production process consisted of different stages corresponding to different artefacts, respectively, representing the product trajectory. Boundary objects highlight technology trajectories capturing the different stages of the production process. Different boundary objects enabled the interaction of different communities of practice [10]. Digital artefacts or models enabled the collaboration and interaction between, for instance, industrial design, engineering and analysis. Different artefacts supported the interaction of different communities of practices, although they pointed out cultural differences. Processes and artefacts seemed compatible at a general level. However, local knowledge embedded into work practices emphasises contextualised skills and expertise. Figure 2.4 shows, in terms of boundary objects, the adoption of a general technology as an integrated repository for different work practices and knowledge.

Similar findings highlighted critical issues in adopting general technology for enabling the collaboration, coordination and integration of different organisational units [11, 12]. The reported studies in [16] highlight critical contingencies in generic technology as enabling organisational memory. Different communities of practice were using different artefacts in order to support configuration management at design and production phases respectively. Both communities of practice were using structural representations in order to capture different system configurations. The structured representations captured local knowledge and work practices. Differences between encoding artefacts, such as diagrammatic representations [15], highlight different work practices and knowledge. The integration of diverse artefacts involves the risk of disrupting work practices by highlighting differences and inconsistencies.

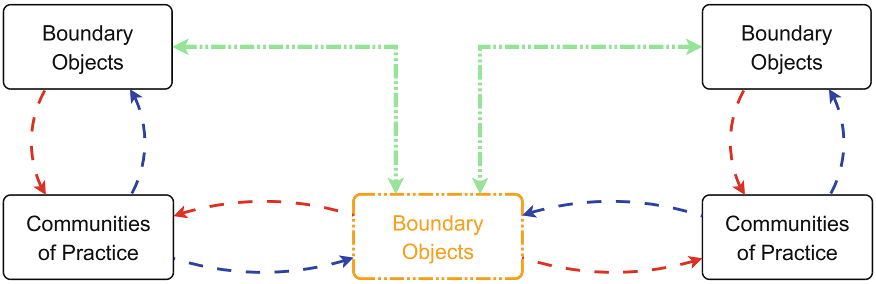

Fig. 2.5 Mediated boundary objects

2.2.2.1 Mitigating Conflicting Knowledge

Generic technology may integrate and substitute existing artefacts, or boundary objects. It, however, requires the identification of coding and decoding procedures (e.g. contextualisation and recontextualisation) in order to support existing work practices, often capturing diverse knowledge, expertise and culture. A lack of support for these processes affects the effective deployment of new technology as innovation strategy. Loosely coupled work practices and technology provide limited support for existing organisational knowledge and procedures. Organisational procedures carry critical knowledge that effectively deals with (or mitigates) design faults or knowledge discrepancies. The introduction of new technology faces these issues, which take the form of failures, process inefficiencies or conflicting culture and work practices. Beside the introduction of new technology, therefore, it is necessary to identify those processes mediating and coordinating existing knowledge embedded in current work practices. Figure 2.5 shows the mediation of local knowledge with respect to communities of practice adopting different, maybe, conflicting, boundary objects.

> Processes of coding and decoding local knowledge would allow new generic technology to articulate current work practices. These processes represent boundary objects enabling the coordination of local work practices and the mitigation of conflicting knowledge. They involve negotiations between communities of practice, who would, eventually, acquire new knowledge configurations by alternating processes of membership and naturalisation. New technology indirectly relates to existing organisational knowledge coded in naturalised boundary objects. Membership allows communities of practice to fix arising discrepancies into boundary objects. Whereas, naturalisation, the other way around, allows communities of practice to familiarise themselves with emerging knowledge configurations. The underlying mechanisms (in terms of boundary objects, communities of practice, and processes of naturalisation and membership) highlight the *co-evolutionary* nature of introducing

new technology into work practices. The evolutionary process may eventually stabilise and emerge as new boundary objects and communities of practice, respectively. The temptation is to enable this evolutionary cycle into new technology. However, it requires communities of practice to naturalise new boundary objects, which could collide due to conflicting knowledge.

2.2.3 Creating Organisational Infrastructures

Complex organisations, such as the ones in the healthcare domain, are often restructuring their infrastructures in order to support diverse challenging competitive objectives (e.g. dependability and performance) and innovations of their processes [27]. The case study in [3, 16] looks at how an organisation in the healthcare domain intends to integrate its information infrastructure. Originally, the information infrastructure consisted of a variety of localised systems and work practices providing and supporting the gathering of patient data.

A central Medical Records unit reporting directly to management was responsible for the maintenance, that is, the coordination and integration, of the different information arising from work practices. This organisation relies on a hierarchical allocation of responsibilities and divisions of labour. The integration of different existing classification systems, or information infrastructures, in a healthcare domain highlights difficulties and contingencies of standardisation strategies advocating general (COTS) technology to fit all work practices [3, 16]. The overall objective is twofold. First, the new system intends to integrate the different systems currently in use across the organisation. Second, the system aims to provide further management control by retrieving comparable data and statistics about different services. On the one hand, the integrated information system was concerned with the improvement of patient care and the accuracy, timeliness and completeness of information used within the organisation for clinical and administrative decision-making. Management was, therefore, particularly concerned that the new system should provide a means for increasing control over performance. This was perceived as a technology innovation enabling the achievement of organisational targets. On the other hand, the integrated information system intended to support work practices by the availability of data providing feedback for research purposes. This would have enabled the various units to move towards evidence-based clinical practices. Figure 2.6, from an organisational viewpoint, shows the emerging organisational information infrastructure consisting of different communities of practice familiar with boundary objects naturalised over several years of experiences.

The case study in [3, 16] analyses the introduction of an integrated *Patient Information Management System* (PIMS) across different heterogeneous units. The system is to provide three main functionalities: (1) it records patient information; (2) it allows users to retrieve historical information about their work practices;

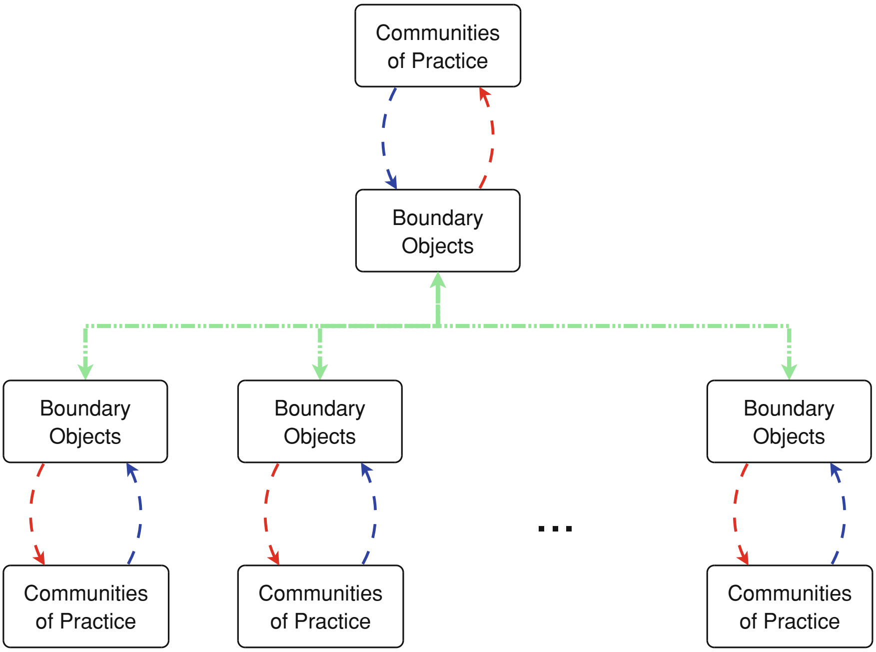

Fig. 2.6 Emerging organisational information infrastructure

(3) finally, the system allows users to analyse data in order to support decision-making and evidence-based clinical practices. The study focused on one component, namely, the *Contact Purpose Menu*, of the new system [3, 16]. It allows users to select among different options from a pull-down menu of activity descriptions. The field is mandatory for each clinical contact. The menu's customisation and evolution proved to be critical for the creation of an integrated information infrastructure. The initial version of the menu simply integrated different options from different existing menus, assuming that the meaning of each option would have been shared among different users and across organisational boundaries and divisions of labour. Figure 2.7 shows some of the categories (forming a classification system) drawn from the contact purpose menu [3].

The move towards an integrated information system represented a shift in *responsibility*. The new integrated information system now requires that members of clinical staff are responsible for data entry relating to patient care. This means that they are now accountable for the *integrity* and *validity* of the information provided. The direct allocation of responsibility and *accountability* over clinical staff increased the perception and the pressure of management control over performances of work practices. Moreover, clinical staff were, forcibly, required to use a tool which poorly reflected local work practices. Heterogeneous artefacts, for instance, paper-based records, often carry on useful information for the smooth coordination of collabo-

Fig. 2.7 Categories in a contact purpose menu

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Assessment
Case conference
Challenging behaviour
Cognitive behavioural therapy
Depot medication
Detox
Discharge
Enabling
Epilepsy
Follow-up
Full assessment
Health promotion
Initial assessment
Lawyer/solicitor report
Maintenance
Management
Mental health assessment
Methadone contract signing
Methadone programme
Methadone review
Not specified
Other report
...
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rations.[2] This is clear from a close look at how clinical staff often organise work practices and clinical judgement in health care. Therefore, the introduction of new tools, such as *Integrated Care Records*, should take into account how to support existing work practices without being disruptive [17]. Unfortunately, such issues arose in the case of PIMS [3, 16]. Figure 2.8 shows how different local systems, artefacts, or boundary objects, were tentatively integrated into the new system. The strategy was one of forcing integration and standardisation across organisational boundaries and divisions of labour, that is, across communities of practice.

The integration was problematic. Clinical users reported difficulties in selecting the available options. They struggled to make sense of the definitions. Moreover, they reported differences with the old system(s). For instance, an old system allowed them to select multiple options for each contact. These problems highlighted how the new system poorly reflected heterogeneous work practices.

Although the system allowed users to select a generic "Not Specified" option, further system usage analysis pointed out that the users were selecting this option rarely. This further stressed the struggle of users in understanding the meanings of the different options. They feared the new system misrepresented and poorly captured

[2] Processes of organisational memory highlight how process trajectories involve "many small memories" [2], or artefacts, capturing the various representational states. Distributed cognition allows the analysis of diverse artefacts, or boundary objects, used in practice in order to accomplish a specific task. For instance, the study in [2] analyses the work practices of a telephone hotline group. Work practices use various artefacts forming the process trajectory—"that representational states take through various memories as an individual process, there are actually multiple group and organizational processes occurring." [2]

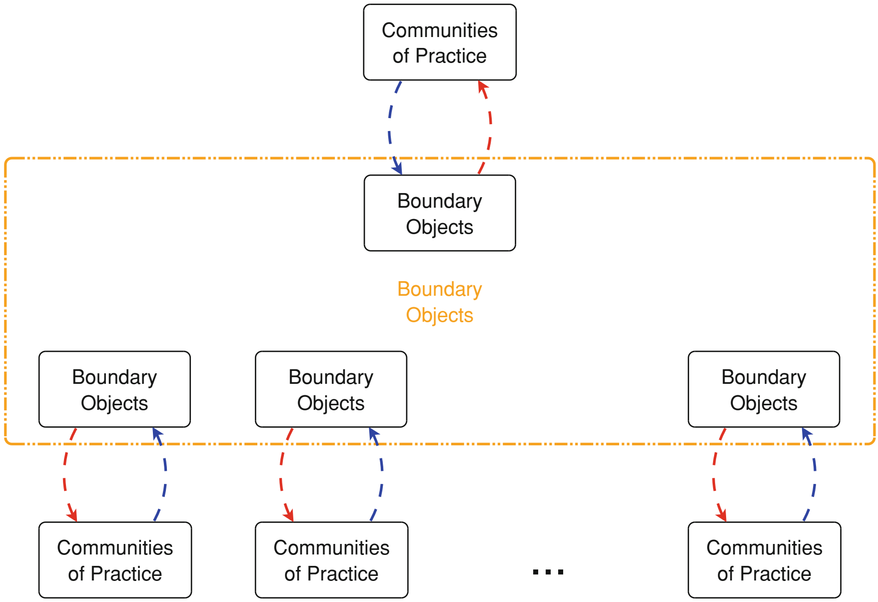

Fig. 2.8 COTS organisational infrastructure

their work practices. Moreover, the figures originated by the system present the hazard of being misleaded in order to support organisational decision-making. This, somehow, affected *trust* between organisational management and local units. The clinical staff perceived a lack of trust in their professional practices and expertise. Establishing the relationship between the general categories optioned by the system and local work practices highlighted the organisational dependency on clinical data. This relationship, once degraded, is a major source of contingencies affecting organisational dependability and performance.

2.2.3.1 Classifying Work Practices

The case study highlights the difficulties in designing and implementing information infrastructures [3, 16]. It questions the underlying assumptions of advocating the delivery of new technology in order to standardise and integrate heterogeneous (local) work practices. It points out that this strategy carries uncertainties, contingencies and hazards. The reported experience illustrates the issues and obstacles of creating an integrated information system, or boundary infrastructure, as opposed to several local information systems, or boundary objects, emerging as a (patchy) information system or boundary infrastructure.

The implementation of localised information systems would be a strategy in order to progressively achieve an organisation-wide information infrastructure supporting different communities of practice. The integration phase would, then, commence once these local systems had been successfully deployed. This provides several consequential benefits. First, organisations can structure and manage information in locally meaningful ways. This aims to maximise the usefulness of the information, ensuring local meanings. Local adaptations are possible and remain local. Second, it allows organisations to delay design decisions about information provided across organisational boundaries or divisions of labour. This, moreover, supports negotiation over any shift of responsibility and accountability for information shared across organisational infrastructures. Third, the costs of sharing information are spread over the different communities of practice adopting related boundary objects. It is necessary, however, to identify trade-offs among such benefits and the costs of maintaining audit and verification with dispersed information practices. Contingencies between trust and dependability may arise due to perceived risk associated with the adoption of new boundary objects.

Shift in responsibility and poorly reflected work practices account for user dissatisfaction of new artefacts. The case study highlights that system design and deployment need to consider work practices progressively. That is, the design and deployment processes need to learn how work practices rely on localised artefacts, or boundary objects. It is a process of learning and adaptation, rather than imposing standardised boundary objects that are meaningless when delivered in other contexts. Moreover, it is evident how information is context sensitive. Information makes sense in local contexts or work practices. The creation of an integrated information infrastructure should be conducted alongside the identification of procedures (e.g. contextualisation, decontextualisation and recontextualisation [1, 2]) to translate knowledge. These procedures, on the one hand, allow information to be generalised in order to acquire a shared meaning across organisational boundaries, on the other hand, they allow information to be adapted and enriched in order to make it useful to local work practices and objectives [3].

The study highlights issues in the deployment and use of information systems across heterogeneous communities of practice [3, 16]. These issues represent sources of undependabilities for the success of technology innovation and the effectiveness of organisational practice. Improved awareness allows organisations to minimise and mitigate such problems when implementing this type of system. Moreover, the analysis of *Boundary Hazards* helps to identify the areas where difficulties can be expected to arise. It is possible to identify three distinctive critical activities [3, 16] involved in defining and deploying a classification of work practices in an organisational setting.

1. *Constructing a classification* involves both amalgamating the local classifications, which arise within the communities of practice. Moreover, at the level of the overall classification, it considers example cases and how they fit into the classification.
2. *Using the classification* captures the practice of classifying cases as they arise in the course of everyday work. This requires the understanding of process trajectories as shaped by the classification.
3. *Analysing informationin classes* involves the construction of statistical analysis over the classified data.

Each of these different activities engages with different communities of practice to varying extents. Different communities of practice have different concerns and needs for support in their activities.

2.3 Boundary Hazards

Developing and implementing new organisational information systems necessarily involves reaching agreement, implicitly or tacitly, about knowledge. Various decisions affect how to classify information, how to represent it through the choice of boundary objects and how to access it. Detailed focus upon the design, implementation and use of information systems allows us to consider various opportunities that may exist either in terms of improved change management procedures or systems to deploy information systems effectively and dependably. Organisations adopt different strategies in order to deal with similar problems with respect to information infrastructures, or boundary objects (infrastructures). Technology solutions address this problem differently, sometimes locally or, alternatively, at an organisational level. In other cases, organisations adopt existing solutions as established standards or classification systems. However, transfer of knowledge, from its local origin to a standardised classification, or across organisational boundaries and divisions of labour, may affect local knowledge and undermine currently existing work practices. Organisations failing to understand and to treat carefully boundary objects (infrastructures) are likely to experience disruptive consequences, which represent significant threats to the dependability of information systems. These hazards may affect knowledge with potential critical consequences for organisational activities and objectives. Technology integration and standardisation, or innovation strategies, although they often involve solutions (e.g. COTS systems) outside direct scrutiny, expose organisations to a set of hazards (across organisational boundaries or divisions of labour) involving boundary objects, or infrastructures, hence *Boundary Hazards*. Table 2.1 summarises and describes the different Boundary Hazards identified by the case studies.

Table 2.1 Boundary hazards

Hazard	Description
Exposed diversity	The restructuring of boundary objects (or introduction and creation of new ones), or boundary infrastructures, exposes organisational diversities. On the one hand, it highlights diversities across organisational boundaries in terms of work practices and knowledge. On the other hand, standardisation reduces organisational diversity
Conflicting knowledge	Integrating or merging different boundary objects embodying local knowledge highlights conflicting knowledge or differences among communities of practice
Lack of coordination	Boundary objects stretch organisational deficiencies in coordinating transfer of knowledge
Shift in responsibility	Boundary objects, or boundary infrastructures, allocate responsibilities across organisational structures and divisions of labour. Changes in organisational boundaries, due to changes in boundary objects, result in shifts in responsibilities
Loose coupling	Boundary objects expose loose coupling, between work practice and knowledge, misrepresenting communities of practice
Mistrust (or lack of trust)	Communities of practice perceive the use of boundary objects in order to centralise control over work practices as a lack of trust. They develop mistrust across integrated boundary objects
Lack of cooperation (or competitive behaviour)	Different communities of practice develop competitive behaviour, or lack of cooperation, in order to gain control over boundary objects and exert their policies (power) over others

Comparing the very different organisational settings of health care and high-technology industries highlighted the influence of sustained efforts geared towards technological innovation, formalisation and standardisation activities in different domains. The case studies analysed problems of working with and evolving classifications of work procedures, which are central to the organisational objectives of new systems. They concerned the need to address the dynamics of standardisation (encompassing both the formation and implementation of standardisation). The analyses allow us to reflect on the methodological implications of needing to address *Boundary Hazards* concerning designing and evolving technology innovation. The results draw attention to the contradictory implications of standardisation efforts. Standardisation faces discrepancies between standard schemes and local practices, which are rooted in existing heterogeneous information structures. It can yield a sense of increasing general accountability, scrutiny and control over distant activities. This can also result in a loss of local focus and detail oversight. The visible alignment process thus initiated may, at least in the short term, encounter or set into play resistance in the organisation. This may be a source of new undependabilities. The contradictory effects of standardisation efforts go to the heart of questions of trust, in particular, to the (misplaced) assumption that standardised information structures and practices can resolve the problems of trust in complex and (spatially and culturally) dispersed organisational settings.

2.3.1 Addressing Boundary Hazards

The investigation of *Boundary Hazards* highlights different strategies as contingency actions mitigating the technological risk related to evolving boundary objects or infrastructures.

- *Restructuring boundary infrastructures* addresses the issues arising with loose coupled boundary objects and work practices. It allows increased controlling and monitoring over the adoption and local tailoring of boundary objects. This enables communities of practice, on the one hand, to shape boundary objects according to their local needs, on the other hand, to naturalise emerging boundary objects in their work practices.
- *Mitigating conflicting knowledge* concerns the integration of different boundary objects. It allows organisations to address inconsistencies of knowledge across organisational boundaries. It involves processes of coordination and translation between local and general knowledge characterising boundary objects adopted by communities of practices.
- *Classifying work practices* captures local knowledge embedded in work practices and relevant boundary objects, which translate across organisational boundaries in a difficult way. Moreover, it takes account of responsibility shifts, which are due to misrepresentation (into boundary objects) of work practices.

It is possible to draw two sets of recommendations. The first concerns information system designers. The challenge now is how to design systems that support diversity in culture and work practices. Beside acknowledging work practices, design needs also to support local flexibility while at the same time continuing to perform a strong coordinating and integrating function. Hence, designers also need to conceive systems that enable an organisation to align with evolving objectives over time.

The second set of recommendations concerns management practice. The challenge in this case is the need to enforce standards while taking into account the different levels and types of diversities and needs for differentiation that are specific to each individual organisational context. The principal challenge for managers remains to identify trade offs between specialised ad hoc solutions and general ready-available ones (e.g. COTS systems). Moreover, any decision affects the level of pervading of boundary objects into work practices. This also affects the extent of coordination and control over communities of practice. These strategies and recommendations provide guidelines for organisational practices and future research.

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