L. Bannon, I. Wagner, C. Gutwin, R. Harper, and K. Schmidt (eds.).
ECSCW'07: Proceedings of the Tenth European Conference on Computer Supported Cooperative Work, 24-28 September 2007, Limerick, Ireland

"…and do it the usual way": fostering awareness of work conventions in document-mediated collaboration

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Abstract. In this paper, we concentrate on how conventions among practitioners are put at work for the sake of cooperation in those work settings where coordination is mediated at a large extent by complex webs of documental artifacts. Our case study focuses on *coordinative conventions* exhibited in the hospital domain and mediated by compound patient records. We conceive of the provision of *document-mediated awareness information* as a "learning device" by which these conventions can be made explicit in all those situations where practitioners need support in coping with and solving cooperative problems in the articulation of their activities. To enable such a context-dependent and user-centered provision of awareness, we also present and outline the WOAD framework that provides users and designers with a conceptual model and language aimed at facilitating the construction of a convention- and collaboration-aware layer on top of traditional architectures of electronic documental systems. To this aim, we take the case of the Electronic Patient Record (EPR) as paradigmatic.

Awareness as a "device" for local conventions

The idea of considering the provision of suitable awareness information as a way to support cooperative work by facilitating the learning of work-related conventions and their inclusion into practice was first seminally introduced by Mark (Mark, 2002). We share Mark's suggestion to address the requirement of establishing and maintaining appropriate conventions within a distributed group of cooperating actors in terms of *collaboration awareness* as "an active learning device", i.e. as a means that takes the innovative function of helping cooperating

partners to learn about each others' conventional ways to coordinate; and even of *shaping* these normative conventional behaviors. Moreover, we share the idea of providing actors with *awareness on conventions* in order to reinforce (or better yet, *promote*) desirable behaviors and to encourage the "correction" of undesirable behaviors in the group. Our common assumption here is that making conventional behaviors explicit and, above all, making actors aware of them *only* whenever these behaviors are suitable for the current context might support actors in making apt and timely decisions on how to proceed with their work, on the basis of well-founded expectations of others' behaviors. Instead of focusing on distributed groups, as Mark did, we rather focus on groups where communication and coordination are mediated by a web of cross-referenced documental artifacts, i.e., on *coordinative conventions regarding the use of complex document systems*. Instead of providing users with *further* information besides what documents show, we propose to change the *way* the same documental content is provided. In doing so, we aim to make actors more aware of the work conventions which are based on documental content; and also reduce the risk of information overflow that Mark said occurs once users have fully internalized cooperative models of usage. In synthesis, we propose considering awareness information as a "*reactive presentation device*", by which conventions are made present-at-hand when needed. Awareness provision is aimed to (a) foster fruitful and on-the-point-of-work discussions about the conventions put at work in the given cooperative setting (i.e., on what is usually "taken for granted" and can hence lead to unexpected breakdowns if not actually conformed by all the stakeholders involved); (b) to mildly and unobtrusively remind actors of how-and-when their colleagues rely on actions made upon the documental content, and (c) to facilitate working habits on proper documentation settle into place seamlessly, especially in the case of apprenticeship and frequent collaborator turnover.

In the next sections, we give the reasons for our focus on *document systems* – either paper-based or digitized– and their coordinative role in cooperative work settings. Giving some examples from our field studies in the hospital domain, we propose the concept of *coordinative convention* as a general umbrella that encompasses conventional practices –e.g. of using documents, of naming and classifying things– by which actors articulate their activities seamlessly. During our study and empirical observations, we identified several coordinative convention regarding document use for both information production and retrieval and gave this kind of convention the name of *document-mediated coordinative convention*s (DMCCs); accordingly, we also use the notion of *document-mediated awareness* (DMA) to answer the question of "what can actors be made aware of, when reading or writing official documents?". Lastly, we illustrate an example of computational mechanism that correlates contextual conditions to occasions for providing DMA for the sake of CC promotion and support; and we outline the functionali-

ties of DMA provision that we agreed upon with practitioners in order to augment documental systems with a CC-oriented support*.

The silent work of documents

Documents are used extensively by practitioners in the execution of their own work and as a means for sharing information with others (Hertzum, 1999) and they manage the flow of information throughout the enterprise. For this reason, researchers from different disciplines have been studying the ways and extent documents are used and managed within professional practices for a long time. As a result, evidence has been collected from very different settings of how documents (far from being mere subsidiary tools where bits of information are passively stored) are woven into work activities and part and parcel of those activities that characterize work in its purpose and sense (e.g., Malone, 1983). On the other hand, the transition from paper-based traditional documents —and the correlated habitual practices— to their fully digital counterparts and to practices intended to exploit these new functionalities, has proven to be highly problematic (e.g., Braa et al., 1998, Sellen et al., 2003). Consequently, the role of documents in work practices has become a central point of interest in several and complementary research fields, and its analysis from observational and ethnomethodological approach has become a way to inform a proper design of computer-based documental systems. Recent studies have considered that documents are not to be regarded as isolated artifacts, but rather as intertwined in a heterogeneous network of people, places and other artifacts used to support communication and the articulation of work activities (Braa et al., 1998, Bardram et al. 2005). In the observational studies we undertook, we found confirmation of other contributions from the specialist literature (e.g. Luff et al., 1992, Berg, 1999) reporting how documents, as versatile and flexible coordinative artifacts (Schmidt et al., 2002), play an essential role in coordinating work and enabling synchronous as well as asynchronous collaboration.

In this paper, we concentrate on document systems that are compounded by a network of mutually cross-referenced documents that mainly play the role of *records*, i.e., official, inscribed artifacts that are written to preserve memory or knowledge of facts or events which have occurred in a cooperative arrangement (cf. the *accumulative* function Berg refers to in (Berg, 1999)) and to support the articulation and coordination of work activities that are tightly coupled with data production and consumption (cf. their *coordinative* function). Such systems are collections of *templates* in-use that we call *webs of documental artifacts* after the suggestive account of a *web of coordinative artifacts* described in (Bardram et al., 2005). More specifically, we focus on the role that these webs play in mediating

* This work has been made possible by the F.A.R. grant of the Italian Research Ministry.

and supporting cooperative work, especially in those arrangements that are not necessarily highly physically distributed, but in which practitioners need to heavily rely on asynchronous communication to articulate their decisions and interventions on multiple and complex trajectories of work. After having surveyed works on the use of documents for information sharing (e.g., Bannon et al., 1997, Harper et al., 1995), we conducted a field study to uncover how physicians and nurses coordinate with each other in two wards of the same regional teaching hospital by means of their official documentation, the patient-centered *clinical record* [1]. In order to envisage supportive functionalities, we observed situated practices of making sense of records that characterize how hospital practitioners articulate their actions across wards and shifts and along different clinical cases while relying on local conventions and ad-hoc agreements. From the method point of view, we followed a "quick and dirty" approach (Hughes et al., 1995): we undertook observations in the wards in as much an unintrusive way as possible and intertwined them with informal and semi-structured interviews with key practitioners to discuss the results of our observations and to collaboratively identify problematic situations and technological means that could play a role in alleviating the uncovered problems. In the last part of the study, we mocked-up these supportive means using the WOAD computational framework (read more below), and we used the mock-ups as a basis for further discussions about the optimal functionalities by which to promote document mediated awareness.

The nature of conventions in cooperative work

In our research, we used the term *convention* with the common-sense meaning of 'shared agreement and related practice that is either established or consolidated by usage'. In what follows, we denote as *coordinative conventions*, those conventions that regard *modalities* by which practitioners *articulate their activities* in any mutual cooperative effort. Among the myriads of coordinative conventions that can be detected in any cooperative arrangement, we will focus on *Document-Mediated* Coordinative Conventions (in the following, DMCCs or just CCs), i.e. conventions that regard how and when documents are used to either articulate or document work activities. Coordinative conventions are usually formed in an *ad-hoc* manner with respect to the domain and work arrangement at hand and can be considered as fairly flexible agreements that actors share on 'what should be done if a certain condition occurs' (i.e., actions), or about 'what a certain condition means from the coordination point of view' (i.e., interpretations). Following Lewis (Lewis, 1960), we also consider CCs as "regularities in the behavior'', which actors of a cooperative arrangement *prefer to* conform to, relying on the

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1 Other authors prefer speaking of patient records and call electronic patient records (EPR) its digitized counterpart. We will use the EPR acronym for its widespread use in the specialist literature.

fact that also others do, so that mutual coordination and comprehension is facilitated. The expression "prefer to" hints two important aspects of CCs: on the one hand, conformance to CCs is a voluntary act, that is not imposed by an organizational entity (either role or unit) acting as a superior authority. Even when conventions are established *intentionally* and do not simply emerge from habitual practice, actors follow them since they want or need to, not because some organizational entity has forced them to. On the other hand, conventions are conformed to since they are *worth* complying with, even irrespective of the number of actors that have agreed upon them. In fact, differently from Lewis, we prefer to relax the requirement that "everyone or almost everyone" has to conform to a behavior to make it a convention: we rather conceive of conventional use of documents as any *meaningful habit* that has been established between actors, even between two single ones. *Reciprocity* is hence the condition 'sine qua non' by which conventions can be applied, since they are built upon and are part and parcel of the common ground that is essential for any ensemble of actors to cooperate and even communicate with (Mark 2002, Schutz, 1970). This common ground is by nature cumulative and is developed as actors share experiences and solve coordination problems while on the job. Consequently, conventions are also temporary agreements, i.e., they slowly change according to what actors agree upon by managing in conventional ways. This aspect of CCs calls for the intertwined requirement that conventions must be *flexibly* defined (and possibly redefined) and applied. Since our main concern is the design of computer-based technologies that are supportive to cooperative work, we make an important point about the difference between conventions and what are usually called *business rules*, especially in regards to policies and organizational requirements on document use and work reporting (Cabitza and Simone, 2006). From the information systems point of view, business rules are commonly conceived as the definitions, operations, and constraints that pertain to *which data* can be processed and *how* these data can change in the ordinary achievement of business goals. Business rules, different from conventions, are intrinsically normative and are set "from above", i.e., by the management of an organization, in order to "mold" document-based business practice, rather than to be influenced by it. Consequently, the corresponding *business logic* that is to enact these rules into an electronic document application is usually hard-wired in the data schema and manipulation methods that the users of a organizational information system are usually provided with. In an organizational domain, the functionalities of institutional document systems tend then to mirror the constraints and needs of business rules, and the rigidity due to their hard-wiring into even complex work-flows is deemed by management more as an opportunity for compliance and efficiency, than as a hindrance to smooth "practice flowing", as often reported in the CSCW literature (e.g., Florijn, 1994). Conversely, CCs are the expression of the users' needs and spring out from practice, which not necessarily is a "best practice" (besides for those who prefer to conform to the conven-

tion) nor an *institutional* praxis. Conventions on document use thrive for their local and possibly temporary ability to solve and even prevent coordination problems on an ad-hoc basis. For this intrinsic difference, for the temporary, voluntary and local nature of conventions, our point is that DMCCs should be treated differently from business rules and be addressed by a *logically different* layer "on top of" the hard-wired application logic of electronic document systems as EPRs are (see Fig. 1). Historically, EPRs are among the "most closed" organizational applications and hence are a paradigmatic case of applications whose logic can hardly be augmented "from within" with coordinative and user-centered functionalities. Some EPRs give access to their data just after business rules and corresponding constraints have been applied and there is no way to either change or make those rules more convention-oriented. Even if these rules were at some time convention-based, their change would require a massive intervention on the corresponding business logic, rather than a simple rewriting of a specific statement, as in our proposal. This is the most critical case in which the two-tier approach can yield its fruits: irrespective of the way organizational rules mold information, a system endowed with computable expressions of coordinative conventions can provide actors with meta-information in order to make them aware of which conventions on data use are the most appropriate to the intended purpose or current occasion. For this reason, in what follows we concentrate on the medical domain and we take the EPR as paradigmatic case for our reflections.

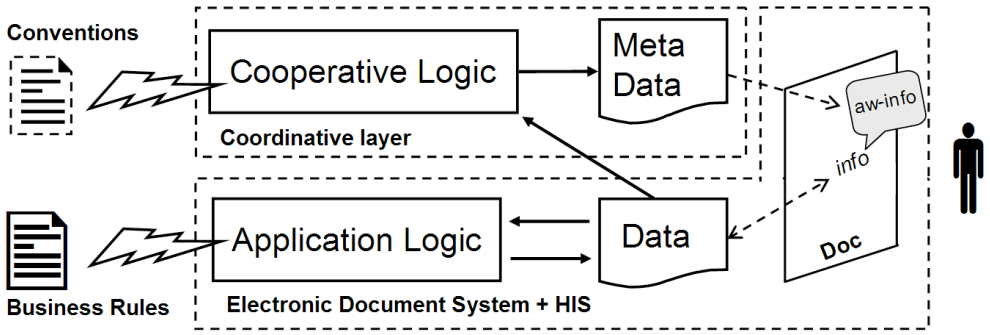

Fig. 1 The two-tier architecture to enhance closed electronic document system with collaboration awareness. Aw-info in the balloon stands for awareness information.

Coordinative documental conventions in hospital work

The clinical record is the main documental artifact used in hospital care as the composite repository for the information concerning a single patient stay. The clinical record can be further decomposed in two partly disjointed sets of documents: the medical record and the care (nursing) record, where doctors and nurses are supposed to document their interventions and activities, respectively. Indeed,

the dyad medical- and nursing- record constitutes a clear and impressive example of *web of documental artifacts* since they are not intended as watertight compartments and each of them is consulted as a unique multi-page artifact only at patient's discharge from the hospital: during the patient's stay, the whole clinical record is split up into several sheets and documents scattered throughout the ward, each being very specific for a certain aspect of care and hence possibly used by different actors at the same time. In order to circumscribe the object of observation, in both an Internal Medicine ward and in a Neonatal Intensive Care Unit (NICU) we have focused on a family of artifacts that within the clinical record are called *single sheets*. They are denoted as "single" since they are sheets conceived to integrate in one single sheet sections which for their function should be parts of either the doctors' or nurses' record. Single sheets are used by physicians to order drugs, prescribe treatments or referrals and establish particular therapies: in short, they are supportive tools and "mediators" of the so called Physician Order Entry (POE). The POE is one of the most crucial document-mediated coordinative moments in hospital work. In the POE doctors give nurses orders about either diagnostic or therapeutic interventions, and nurses give doctors clinical accounts upon which doctors can take appropriate clinical decisions, though with a rigidly differentiated assignment of concerns and responsibilities. The artifacts used in the POE then mediate two kinds of coordinative behaviors: a more *prescriptive* one, in which doctors commit and delegate nurses to accomplish an intervention on the patient and nurses make themselves accountable for that intervention to be executed as doctors expect; and a more *descriptive* one, where nurses give doctors feedback on the completion of the related task and corresponding clinical data, thus enabling further activities that were waiting for the order execution. In both cases, conventionality plays a fundamental role as we are going to illustrate in the following sketchy vignettes.

Conventions on proper timing – Documental artifacts can be used to convey meaning besides what practitioners annotate on them, i.e., by means of their boilerplate contents and structure. For instance, in the case of the prescription of laboratory tests, the doctor requiring a test is supposed to indicate whether the examination is urgent or the blood sample can be taken and sent to the laboratory with all the other routine examinations. Since the indication 'routine' conventionally refers to the next day early in the morning, for routine examinations the physician is usually exempted from recording the precise time and even the date of the request. Conversely, for requests marked as 'urgent' this indication is necessary because only in this way nurses can correctly prioritize due tasks and realize whether they must hurry up and take the blood sample. The conventional nature of urgency was made clear during our observational studies in both the observed Internal Medicine ward and NICU: at the former ward, whenever the doctor checked the 'urgent' box on the single sheet for a request, she meant "please, send me back the lab results in half an hour", while at the NICU, "urgent" meant "right

now" with no exception, due to the typical critical conditions of the admitted premature newborns. Right timing on order completion is therefore a clear example in which unwritten CCs are at work, specifically on the notion of urgency that is taken for granted in a given setting with all the coordinative consequences of deeming something urgent: for instance, consider the CC by which nurses make sense of the time elapsed from a request, in order to understand whether they are late or not about an order. Or the CC by which nurses are supposed to explicitly notify doctors that lab reports have just been sent back from the lab and are ready to be reviewed (as in the case when they are urgent) instead of letting doctors look the reports up in the clinical record on their own. This and the following considerations must be seen in the light of technological support to work: therefore the point on proper timing CC is not whether ward practitioners need to be supported in realizing what an urgent order means every time, but rather it is how a digital documental system could remind them of urgent orders *at an appropriate time*.

Conventions on proper redundancy – In a previous analysis of cooperative work in the Internal Medicine ward (Cabitza et al., 2005), we pointed out the manifold ways the phenomenon of data redundancy occurs in the daily documental work of nurses and doctors, and we denoted with the expressions *redundancy by duplicated* and *replicated data* those cases in which the *same* data are reported either in two or more documents of the clinical record or in different points of the same artifact, respectively. Also at NICU, redundancy can play an important role in supporting both coordination among practitioners and their decision making. For instance, it is only on a conventional basis that members of a specific NICU team want to have data on the weight, age and height of newborns reported in every single sheet of drug prescription only when a newborn is in life-threatening conditions. Conversely, the fixed and good-for-the-whole hospital business rule on data replication that is irrespective of patients' condition would neglect this local and team-based conventional requirement, and expose practitioners to the risk of both being provided with irrelevant and overloading information and losing the unobtrusive reminder on critical conditions that the presence or absence of this data could play at the very point of order entering.

Conventions on proper compilation – A similar case regards the infusional therapy sheet and the conventions we observed pertaining to whether a compiled sheet is considered complete/accurate or not within some practitioners' community. At the NICU, nurses are conventionally used to not reporting liquid intake values –or to reporting them only by a rough estimate– whenever these values are within normal range for two main reasons. On the one hand for the sake of conciseness; on the other hand, to convey an implicit reminder that "all is well" to the colleagues of the next workshifts. We then observed how traditional dimensions of data quality like accuracy and completeness, which are usually taken as intrinsic to a document or data set, assume a more conventional and context-dependent nature in a highly dynamic and frantic domain which clinical work is. We also ob-

served that actors perceive how well work is documented depending on local conventions, which determine what fields are really mandatory or what could be the most convenient order of their compilation on the basis of the current workload and kind of work (e.g., whether critical or stable patients). This is also a case in which CCs and the business logic of a Hospital Information System (HIS) could be discordant with each other in that administrative managers and biostatistical researchers could have their quality requirements (e.g., for accurate and complete clinical data) embedded into the EPR forms and workflow in terms of corresponding constraints that straightjacket the coordinative and informational needs of clinicians at the point of care (Cabitza and Simone, 2006).

Conventions on documental content – The variable content of a document, i.e., what is jotted down in the clinical record by practitioners in the act of documenting and making their daily work accountable, can be produced and consumed in the light of conventions that affect the very meaning it conveys. For instance, as a result of a long and continuous frequenting of its members, in almost any ward a pretty complex but still yet unofficial jargon can end up by developing and thriving, a jargon by which medical terms and habitual examinations and treatments are abbreviated in shorthand. As the novices and frequent job-hoppers that we interviewed confirmed to us, besides pretty ordinary ways to shorten medical expressions that are common to a certain discipline or scientific community, also other much less common naming conventions are employed, especially in spoken language. For example, in the very same hospital, practitioners referred to their ward as either 'reparto' or 'divisione', or with abbreviations such as U.O. (for Unità Operativa) or S.C. (for Struttura Complessa) according to their length of service: corresponding "ward-wide" conventions became then consolidated according to the average age of ward staffs. These and similar conventions, once introduced even by chance within a certain group of practitioners, then become more and more consolidated over time, either by sheer habit or even for the often implicit intention of fencing off outsiders or ward patrons that are better not to catch every thing said in the ward (e.g., patients or their relatives). While cascading and drop-down menus employed in EPR pages and forms usually disregard these local abbreviating conventions or, even worse, tend to impose their own "standard" acronyms, doctors usually fill free-text fields with these ward-wide abbreviations. Forgetting these conventions in design undermines the effectiveness of any computer-based support for the mutual articulation of ward activities.

Conventions on document-based practices – Other times, naming conventions come from the clash between precise marketing strategies of pharmaceutical companies and regional-wide or hospital-specific drug supplying policies: practitioners make sense of what is written on clinical records from these conventions. It is on the basis of these conventions that some doctors prescribe name-brand drugs while, in so doing, they mean any drug with the same active principle; or that, viceversa, nurses administer specific branded drugs instead of others once that

doctors have prescribed a generic drug. The point here is that doctors and nurses cooperate about pharmaceutical treatment more on the basis of ward- or even doctor-specific conventions, rather than on what it is actually written on the single sheets. Again, forgetting these ordering conventions undermines the effectiveness of automatic drug dispensers (Balka et al., 2007) and can hinder their actual inclusion in clinical practice.

We also observed a set of even more articulated conventions that – consolidating *across*, rather than *within* single wards– "regulate" how nurses should prepare patients for certain treatments or tests, especially when the latter are accomplished in an external facility or another ward. EPRs and request forms are usually intended to mediate the booking of a time slot at the external facility and they limit themselves to supporting just the "scheduling" dimension of articulation work between multiple wards: instead, the *pragmatic* dimension of articulation, i.e., handing over patients so that their care trajectories result in no seams or discomforts, is left to the ad-hoc externalization and combination of CCs across different communities of practice. The fact that a patient must fast a predefined number of hours before undertaking a test, or that she must be provided with either a local or systemic sedative and even how and to which extent she should be informed about the very sequence of treatments she will undergo, is a matter of more or less externalized conventions between nurses of the referring and of the accepting wards. We have seen as frustrating and unrealistic how it can be to try to embed these conventions into any business logic that is irrespective of doctors' idiosyncrasies, particular testing modalities and other contingencies.

What actors need to be aware of

Within the CSCW community, recent surveys have ended up by listing and describing up to nineteen different types of *awareness information* (e.g., Jang et al., 2000). In these and similar listings, researchers have tried to shed light on the manifold and often very situated use that actors can make of some specific (usually visual) information to become aware of aspects related to the current work, like "what others are doing" and "where they are" (Gutwin et al., 1997, Bång and Timpka, 2003) in order to fulfill either tacit or explicit informational needs. Generalizing the situated phenomenon of awareness can be useful to detect common features and recurrent patterns of provision of this kind of information and hence to extract similar requirements for a supportive technology. Nevertheless, one should never overlook the domain *specificity* of awareness information: much of what an actor needs to know about others heavily depends on the application domain. Moreover, the very nature of the awareness information provided depends on the very means actors use to get this information. For this reason, in our study we have concentrated on *document-mediated awareness* (DMA), i.e., awareness that can be conveyed through documents. DMA concerns either document content

or the work practices that closely relate to the basic ones of reading and writing. We collected requirements about DMA provision mainly by (a) interpreting what the users of the reference document system -i.e., the clinical record- did and said in light of some awareness aspects selected for their relevance on specialist literature; and (b) by explicitly challenging these interpretations during scheduled interviews by means of some "key questions" that were inspired from those proposed in (Schmidt 2002) and (Gutwin et al. 1997). The questions and answers we collected led to drawing up a list of "kinds of awareness" that, far from being comprehensive of all the possible nuances, is oriented towards what interviewed practitioners have claimed are their awareness needs and desirable support about "conventional" articulation work. The main reasons why actors felt they needed to be reminded of conventions lay on the wide range of different needs that novices and experts perceive as the most urging. The former ones advocated awareness provision as a support for their 'practice learning' and inclusion in the ward habits. The latter ones appreciated the possibility of being reminded of conventions when hectic action and frequent interruptions could hamper their full and seamless compliance to them. The list of awareness kinds detected by explicit interviewing encompasses:

Browsing awareness - This kind of awareness can be provided when a certain textual item (e.g., a content entry, a whole passage) is recognized as correlated (e.g., hyperlinked) to some other ones, possibly in different documents (what has been called *redundancy by supplementary data* (Cabitza et al., 2005). The provision of this kind of awareness concerns the aim of supporting data interpretation and mutual consistency of correlated data.

Alerting awareness - This kind of awareness can be provided to make actors aware that there is something (that can be purposely left underspecified) that must be checked about what they are reading or writing since things are not going as expected (obviously with respect to some convention). The intentional underspecification of this kind of alert is conceived to find application in domains characterized by openness, ambiguity and unpredictability. Let us consider the case in which the convention of a hospital ward states that, whenever the temperature of a patient is higher than forty degrees, an alert should be raised to the accountable nurse: this case is about alerting awareness for "absolute conditions". Conversely, let us consider a "subtler" convention about "relative conditions". The doctors we interviewed during our field studies gave us the significant example of operated inpatients, whose low blood pressure is normal *unless and until* signs of an anaemia also show up, when that could be an indication of internal hemorrhage. Similar conventions can be applied to all those cases in which data become significant only after insertion. In those cases, an alert should be raised as soon as a vital sign becomes serious under some other condition, although when it was reported into the documental system it did not raise a particular warning since under the contextual conditions it was negligible.

Provisionality awareness - This kind of awareness can be provided according to conventions by which, in a given cooperative arrangement, either data are consolidated or committed to some official repository. Or alternatively, according to conventions by which data are purposely conveyed as still provisional and pertaining to an unfinished job. For instance, in the paper-based practices we observed, actors often relied on the convention that if notes were (still) written in pencil, then practitioners *did* have to consider those notes but were to take them as not yet definitive, or even as an invitation for further checking. The need for actors to be aware of what is still provisional with respect to what conversely constitutes an unmodifiable and legal account of accomplished clinical deeds is essential to cooperatively structure the formation of decisions and judgments. This holds even when the peculiar affordances of paper-based artifacts are not replicated in their digitized counterparts and their business logic does not specifically address this requirement (Hardstone et al., 2004). In fact, we observed the case of an electronic parenteral nutrition calculator used at the NICU, where actors relied on the convention that values inserted long before the scheduled feeding time were not to be considered definitive, but just as prospective formula so as to prevent unnecessary preparations.

Inconsistency awareness - This kind of awareness can be provided according to either the semantics of the data or more local conventions by which data are considered lacking in consistency with respect to their type or with respect to other data previously recorded in the documental system, respectively. In the former case, inconsistency awareness can regard, e.g., body temperature data that are higher than fifty degrees (i.e., an impossible physical condition), or dates for prospective examinations being scheduled in the past, and similar cases that concern the definition of a data type in a given application domain. In the latter case, inconsistency can regard more abstract aspects of the medical application domain, like that between some drug administration with some particular disease or allergy, or between patient-centered and work-related conditions (e.g., a pregnant woman scheduled for a C.A.T. examination, or a meat-based meal ordered for a vegetarian inpatient). Inconsistency awareness does not necessarily require an amendment, since actors can find a reason to cope with a partial inconsistent state of the world anyway, or even to supersede the business rules by which a sound situation is fallaciously considered inconsistent.

Amending awareness - This kind of awareness can be provided according to either some formal data model or more local conventions by which data are considered mistakes with respect to their type or data representation. This case is slightly different from the former, in that it regards data resulting in syntactic mistakes, like a date where a name is supposed to be filled in, an e-mail address that is filled in without the at sign ('@'), or even a tax number field that is empty (where a predefined 'not available' value is expected for those cases in which such number cannot be timely filled in). This DMA derives from the fact that doc-

tors and nurses deemed any automatic correction in their records as unsuitable and even potentially harmful: they preferred speaking of proper warnings that are raised according to flexible data constraints that have to be taken as maps rather than as scripts (Schmidt, 1997).

Accounting awareness - This awareness information concerns either who did something (or was responsible for, in the case of work activities) or when she did it. According to the degree of granularity of the work context representation, such awareness information can be characterized also in terms of other contextual information besides merely accountability and time: e.g., which was the activity that enabled or triggered the record; where it has been accomplished; whether it is traceable back to some routine task or to a handling of an exception, etc. For instance, a convention holding at the observed hospital wards states that if a certain item has been recorded by a nurse long after the scheduled end of her work-shift, this could mean that it refers to a serious emergency handling and also that recorded items should be taken with some caution. The provision of such DMA is particularly desirable when an actor consults the documentation to interpret the history or log of updates for a certain data field.

Reminding awareness - This kind of awareness information can be provided to point out that some task *should* be executed. It can be used to remind some specific actor or role that it is due time for the execution (or completion) of a previously scheduled task as in the case of urgently due lab examinations reported in the single sheets.

Coordination awareness - This awareness information can be provided to make actors aware of some activity interdependency and hence to prompt them to actively manage it. The provision of such DMA could be sensitive to conditions related to either activities that must wait until some other activity has been accomplished, thus keeping resources underutilized and having other practitioners waste their precious time. For instance, this was often observed when patients had to be brought to external facilities for examinations on a roughly staggered schedule. Coordination awareness could then be conveyed in order to make the actors involved in the blocking activities feel committed and determined in supporting the dependent colleagues.

Enabling/Inhibition awareness - These two DMAs were recognized as very desirable and very difficult to achieve at the same time. In fact, the former was seen as capable of improving uniformity and effectiveness in routine interventions by reminding which alternatives are to be evaluated according to some conventional and referential “best practice”, like in the case of a growing suspicion of GBS infection (Beta hemolytic streptococcus group B). In this case, doctors can be presented with the opportunity to either undertake an antibiotic therapy or just keep observing for a couple of days (the so called ‘wait-and-see’ prescription). Even more significantly, the *inhibition awareness* was seen useful at preventing unconventional or erroneous behaviors in that it can be provided whenever at least

one of the preconditions of an activity are not met by the current context, i.e., whenever some convention or business rule makes actors deem an activity as "inhibited". This can happen for a number of reason, e.g., whenever a "conflicting" activity is in execution, either in regards to its logical precondition (e.g., a drug prescription can not come after the corresponding drug administration) or the use of common but not shareable resources. These resources can be even patients that have to undertake two diagnostic examinations at the same time. Since these DMAs can be provided only when the preconditions of an activity are recognized as either true or false by the current context, only activities that are very specific to a given situation or are critical should be suggested as either *enabled* or *inhibited*. In the former case, actors are suggested to begin the activity, while in the latter case the activity is indicated as leading to unconventional or undesirable situations. In doing so, a potential problem of information overload can be prevented. Moreover, these activities should be clearly identifiable by contextual conditions or by a direct action of the involved actors in order to avoid nagging warnings about what the actor can/cannot do at a given time.

A framework to express conventions and provide awareness about them

As a result of our interaction with the hospital practitioners, we conceived of the above mentioned typologies of awareness as kinds of *suggestions* that the augmented document system could convey to actors in promoting awareness on CCs, irrespectively of the way these types of awareness are represented through proper changes in affordance or formatting of the interface of a specific document system. The identification of proper suggestions requires the cooperative effort of actors and designers to make the relationship explicit and symbolic, which occurs between *recurrent patterns of context* and *conventional, reactive ways* to cope with this context. To this aim, it was natural to express these relationships in terms of conditional statements, i.e. *if-then* statements*:* context patterns are represented in the antecedent (the if-side), while the corresponding reactive behaviors in the consequent part (the then-side), respectively. Consequently, as designers, we adopted a *declarative and reactive (production-based)* approach in defining the computational framework (called WOAD – see below). The idea behind this choice is twofold: on one hand, to keep the same linguistic paradigm; on the other hand, to simplify the translation from an informal expression of habitual behaviors and domain knowledge into a computational formalization; this is accomplished by leveraging on the well known advantages of declarative and production-based approaches in terms of flexibility (Lloyd, 1994) and modularity. Our point is that expressing the conditions by which the main DMCCs must be applied to the current content of documents in terms of simple bunches of reactive code

(i.e., in terms of the if-side of a production) could respond, at least partially, to the urging requirement of frequent tuning, production or dismissal of conventions that regard the electronic document system. In other words, we propose WOAD as a *programming interface* with which to "program" (i.e., make computable) mechanisms of awareness provision about conventions on data use and consumption, at a problem oriented level. In fact, WOAD users can concentrate on the specification of the functionalities supporting the coordination needs of the target setting and avoid considering the technical details of the underlying operational infrastructure. Since our goal is *not* to develop a full-fledged electronic document system but to endow these systems with cooperation-oriented functionalities, we conceive an upper layer of convention-aware application logic that would be conceptually "on top of" them and support awareness provision in a computable but yet platform-independent way.

The WOAD framework

The WOAD framework (an acronym for 'Web of Documental Artifacts') encompasses a conceptual model and a reference software architecture to make symbolic and declarative expressions of coordinative conventions computable by a rule-based interpreter[2]. The WOAD model encompasses a set of high-level concepts – like those of *actor*, *documental artifact*, *fact space*, and *facts interpreter* – that could guide the design of a context-aware and coordination-oriented level on top of electronic document systems. WOAD also provides designers with a set of language constructs – the L*WOAD language – that are made executable by a full-fledged interpreter that enables the distributed and context-aware execution of rules. L*WOAD encompasses a set of both static and dynamic constructs – namely *facts* and *mechanisms*, respectively – by which the designer can express both contextual, organizational and procedural knowledge about a work arrangement in a declarative manner.

Specifically, conventions and awareness provision mechanisms are expressed by two specific constructs: *convention-facts* and the related *mechanisms*, respectively. In L*WOAD, the suffix *-fact* is associated with static *key-value data structures*, by which the programmer can characterize the relevant entities of a documental domain by simply assigning a value to specific attributes. A *convention-fact*, for instance, is characterized by four attributes: a *name*, a *description* and two further attributes, *condition* and *action. Condition* slots contain the symbolic expression of conditional statements regarding either the existence of some facts within the *fact space* (i.e., the memory of the computational system) or, more specifically, some condition over the values of these facts. The *action* slot contains a declarative description of the convention in terms of either conventional behaviors or interpretations (proper sequences of WOAD assertions are usually used to ex-

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2 For more details, please refer to http:// http://www.mac.disco.unimib.it/docs/Cabitza-PhD-thesis.pdf

press this information). It is important to notice that in this notation, CCs are sort of "knowledge" represented as static data structures: they are not intended to generate an automatic or computationally supported flow of work. Instead, they serve as sources of information to conceive mechanisms to provide awareness *regarding conventions*, as depicted in Fig.2.

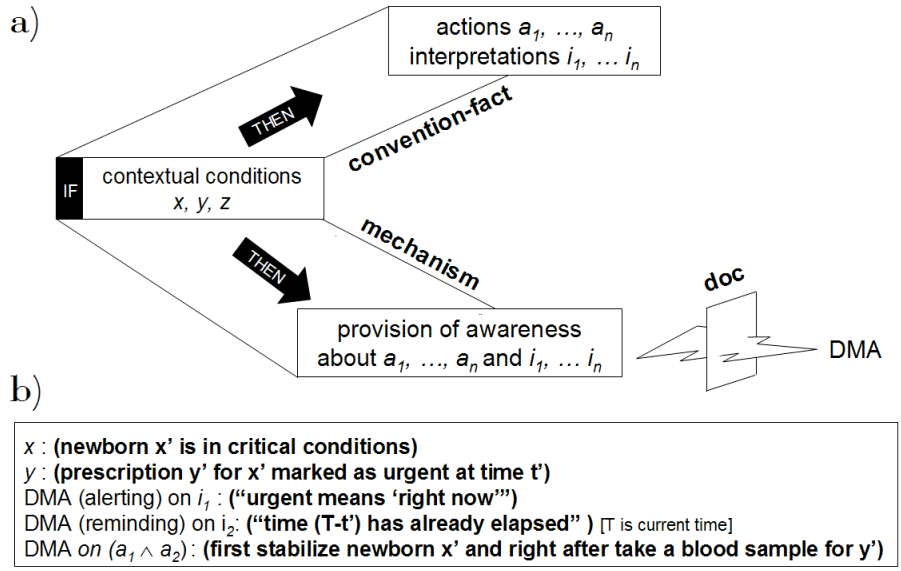

Figure 2.a The relationship between the L*WOAD constructs of convention-fact and mechanism. Figure 2.b An example of instanced mechanism on a NICU convention.

The main rationale behind the design of proper WOAD mechanisms is to support convention adherence by suggesting to actors either which behaviors could be compliant to the anticipations and presuppositions of co-workers in a given situation (i.e., suggestions on what-to-do) or which conventional interpretations co-workers would rely on to seamlessly coordinate with them (i.e., suggestions on what-is-conventionally-meant under specific and well defined work conditions). L*WOAD mechanisms can then be seen as *conditional statements*, like *if-then* rules made of an antecedent and a consequent: the clear similarity between conventions' condition-action pair and mechanisms' antecedent-consequent one is not fortuitous. In fact, there is a tight coupling between *convention-facts* and corresponding *mechanisms*, since they both make explicit the relationship between the *same* contextual conditions and some conventional way to cope with or be aware of them, respectively (see Fig.2.a). The only output of L*WOAD mechanisms is to make explicit what kind of *DMA type* should be provided to users of a document system so that they can recognize the conventional nature of the situation at hand (the shared antecedent), and make sense of it according to locally agreed interpretation and conventions (the consequent instantiated on the actions contained in the pertinent conventions).

From the notational point of view, the consequent part of a mechanism concerning a convention CC_i would contain WOAD primitives that assert (make true) into the *fact space* a corresponding *awareness-fact* representing an awareness message that is provided for actors' consumption at artifact level. Each *awareness-fact* refers to a given class (or type) of awareness information, whose description has been outlined in a previous section. From the template point of view, an *awareness-fact* is a fact with three attributes: (1) as just said, a *type*, which at instance level can be taken from the DMA list or any other taxonomy; (2) a *content* attribute that, at instance level, refers to the piece of information actors should be aware-of. This information can be conveniently rendered as a message –be it either an alert or reminder or whatever according to the awareness type– conveyed to actors in some way through the interface (see next section); and (3) a *source* attribute that, at instance level, encompasses all those facts that constitute the source of the awareness information, i.e., the "reason" for actors' attention, in terms of actual aspects of the current context calling for a conventional action or interpretation (see *x* and *y* in Fig.2.b).

Conveying awareness through documents

The next step was to put WOAD at work in order to construct the mechanisms supporting the identified kinds of awareness within a coherent technological framework. For our "experimental" sessions with some key actors of the ward personnel, the NICU management put a web-based Electronic Patient Record at our disposal that the head physician had commissioned approximately one year earlier from a small local IT firm that had been providing the ward with a number of lean and task-specific applications over the last ten years. By leveraging on the long-time acquaintance and acquired familiarity between the designers of the small firm and some of the physicians working at the ward, a full-fledged prototype of electronic clinical record was built to allow for incremental improvements and further validation by the hospital management. Due to interoperability issues and other red-tape hindrances at the whole hospital level, this prototype was never amended and failed to be fully deployed at the ward, but nevertheless it constituted an ideal platform on top of which we could conceive and illustrate the awareness-providing mechanisms to their intended beneficiaries in terms of "mocking up" sessions, in which the graphical interface was just instrumental and not a primary concern. The goal was to evaluate how properly the uncovered conventions were rendered into WOAD mechanisms calibrated on the prototype's structured pages according to the model of ward conventions expressed in terms of L*WOAD constructs. These "mocking up" sessions led us to collect a number of interactional requirements, that the full-fledged electronic documental platform should satisfy for tow main reasons: to make secretarial work by clinicians smoother; but also, and above all along the WOAD perspective, to make the co-

operative effort between practitioners and designers toward the construction of computational mechanisms supporting DMA easier and more effective. These requirements are not to be intended as valid just for the clinical application at hand or for the clinical ward we studied, but they can also be made more general by correlating them to the main functionalities exerted by documents and to the taxonomy of awareness we propose. Such functionalities can be summarized in the following enumeration: 1) *Function of alerting actors* about data previously inserted by other actors, regarding either inconsistencies/errors or suggestions for their correction. This functionality can be harked back to the requirements pertaining to the archival dimension of the record at hand and to the provision of either *alerting*, *inconsistency* or *amending* awareness. 2) *Function of highlighting data values* that could be useful for actors to consider, so as to provide them with awareness information about linkages with other data and well characterized relationships between what they write (or are about to write) and other data written in the past or by colleagues. This functionality pertains to the articulation dimension of the record at hand. In fact, it aims to support the task of making sense of what is recorded and is correlated with the provision of *browsing*, *inconsistency, accounting* and *coordination* awareness. 3) *Function of highlighting data fields* that users must fill in during a given documental activity (e.g. error-free form compilation); and the correlated function of providing users with information about the *reason and way the form completion must be done*. This functionality pertains both to the archival and articulation dimension of the record (Cabitza and Simone, 2006): the former benefits from a higher data quality (i.e., more complete records, more accurate data), while the latter benefits from a support to documental activities that have some priority over others. This functionality regards the provision of *browsing, inconsistency/amending* and *coordination* awareness information. 4) *Function of highlighting data fields* so that the activities associated with those fields are suggested *as possible choices*; in addition, in the case none of the suggested activities is selected by actors, then *occasion for justification* would prompt them. This functionality clearly regards articulation of tasks: in fact, by the proper highlighting of fields, a corresponding flow of work is suggested to actors along a descriptive rather than prescriptive perspective. Moreover, even when the suggestion is disregarded by actors, a justification space is proposed in order both to increase the accountability of the accomplished deeds and to provide colleagues with the rationale of the deviation from conventional or purely routine work trajectories. This functionality regards the *coordination*, *enabling* and *inhibition* awareness.

Conclusions

The paper presented a research path that combines the study of the literature about the role of documents in cooperative work, with a field observation in two hospi-

tal wards of the practices of coordination and usage of documents from the related clinical record. Our point is that a supportive technology could help actors by providing them with awareness information about in-use conventions. In turn, the interaction with doctors and nurses allowed us to participatively identify different kinds of that specific document-mediated awareness (DMA) information as well as different ways in which these actors would like to be supported to strengthen the mutual adoption of conventions. Since both conventions and awareness provisions are triggered by context conditions, we adopted a declarative and production–based approach to make DMA provision computational and decoupled from any specific implementation platform. To this goal, we developed the WOAD framework, whose main component is the L*WOAD language. By using the L*WOAD constructs, designers can express the relationship between conventions and pertinent awareness information through specific interface functionalities. The approach has been informally tested through mock-up sessions with satisfactory outcomes in terms of clear requirement identification and fruitful discussions about useful interface functionalities. The research path will continue with the full implementation of the WOAD framework, to both consolidate its interoperability with existing document systems (via XML-based API) and improve the interaction between various stakeholders in their joint effort of designing awareness mechanisms and their representation.

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