REA analysis of SAP HCM; some initial findings

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Abstract. This paper explores further the claim that the Transaction-Oriented Architecture (TOA) based on the principles of Resources, Events, Agents (REA) can enhance Enterprise Resource Planning (ERP) systems by providing a principled theoretical basis that can underpin ERP business process implementations. We provide details of some of our initial findings of the REA/TOA analysis which we carried out on the SAP Human Capital Management (HCM) module. Given that SAP is recognized as the dominant ERP system with over 50% of the market share, this technology is viewed as the representative case study technology for exploring the theory of REA in actual ERP systems. In particular O'Leary's and Dunn et al.'s works are expanded upon, substantiating O'Leary's findings that SAP was found to be consistent with REA in its database, semantic and structure orientations. Using SAP's HCM module as the exemplar, two notable discoveries are made. These are namely (i) identifying that several anomalies exist in the underlying data model, and (ii) that there are many more REA entities than previously discovered by Dunn et al. Through the SAP HCM exemplar it is shown that REA adds value to modelling business processes in ERP systems.

Keywords: SAP A.G., ERP, Design Patterns, REA, HCM, TOA (Transaction-Oriented Architecture), Semantics, Ontology, Combining and Unifying Business Intelligence with Semantic Technologies (CUBIST)

1   Introduction

In this paper we explore the claim that TOA can be used following the principles of REA to enhance business process modelling in ERP systems, by providing a tool that can be used to increase the system design and understanding of the business process implementation and the underlying data model.

Fundamental to REA/TOA is the concept of a design pattern, since REA is defined in terms of an object design pattern. A design pattern is a recognized, named solution to a common design problem [1]. Catalogs of design patterns have been produced by the *Gang of 4* as the solution to commonly found object oriented software design problems [2]. The concept of the Transaction Model (TM) was introduced to provide a method of encapsulating the REA model using CG concepts and thus allowing for the capture of organizational transactions by providing abstract constructs [3]. TOA offers the possibility of providing the tools (TM, TrAM, MAS) and concepts required to model the structure and transactions of an organization and provide purpose and direction to Service-Oriented Architecture (SOA) [4].

There are many vendors of ERP software, the top five vendors are SAP, Peoplesoft, Oracle, J.D. Edwards, and Baan. SAP is recognized as the dominant ERP system with over 50% of the market share [5]. Due to the clear commercial importance of the SAP solution, it was considered a logical step to use this implementation as an exemplar for ERP systems.

We provide evidence that shows how REA can be successfully used for modelling SAP business processes (in SAP HCM) and how SAP can be considered in part as complying with REA theories. However, the results of the research also indicate that through non-compliance with the REA ontology, how data is lost or stored again (repeated) within the SAP database. Confirming one of McCarthy's [6] original theories that led to the REA ontology, since he identified that using conventional data storage techniques (such as double entry), would lead to *inconsistency of data*, *information gaps* and overlaps in data or *data spread*.

This paper proceeds as follows. Section 2 contains the core of this paper, by making an REA analysis on one (SAP) business domain, SAP HCM and one business process within this domain, labor (labour) requisition. Section 3 provides a final summary and outlook.

2   REA analysis of SAP HCM

2.1   HR business process

The HR business process is defined by Dunn et al. [7] as encompassing all that is required to acquire and then pay for employee labor. The HR business process is commonly separated into two separate sub-processes, where one sub-process; (i) personnel is responsible for hiring, training, evaluating and terminating employees and the other sub-process; (ii) payroll is responsible for the time management and subsequent payment of the employee's services [7].

2.2   REA Enterprise Value System

In the REA Enterprise Value System the HR business process is defined as the point of contact between the enterprise and its employees [7]. In this sense the employees are seen as external suppliers (external agents) or business partners providing labor to

the organization in return for cash. The HR business process in the Enterprise Value System is identified in **Fig. 1** below.
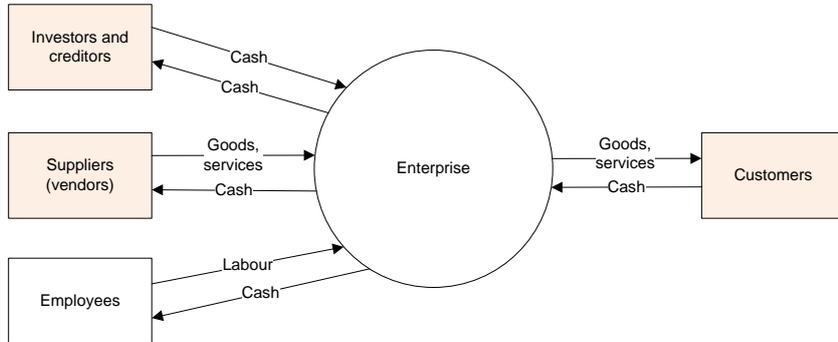

Fig. 1. Payroll Human Resource Process in the Enterprise Value System [7]

Within the HR business process Dunn et al. [7] identify two key forms of resources that of human capital, the labor provided by the employees and the cash paid by the organization to the employee in return for the labor which was provided.

In REA terms the HR business process is identified (**Fig. 2**) as a special case of the acquisition/payment cycle, consisting of four key business events; *labor requisition*, *labor schedule*, *labor acquisition* and *cash disbursement* [7].
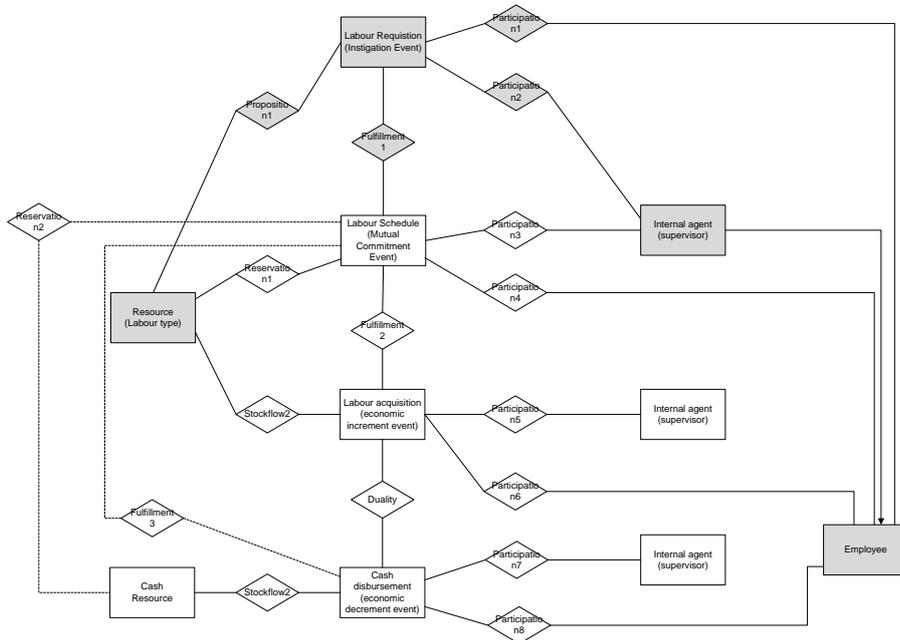

Fig. 2. Payroll Cycle Extended REA Ontology Database Design Pattern [7]

The ideas from Dunn et al. [7] and their initial REA diagram (**Fig. 2**) were used as a basis, from which this paper provides a more detailed investigation into the labor requisition business event which is shaded in grey in **Fig. 2**. These investigations have shown how it is however possible to provide further detail (than that provided by Dunn et al. [7]) of the labor requisition event and subsequently identify new REA entities.

2.3   SAP Human Capital Management (HCM)

The HR module is identified within SAP as Human Capital Management (HCM). SAP HCM consists of three separate sub modules which are identified as *Talent Management, Workforce Deployment* and *Workforce Process Management*. These three HCM sub-modules are then surrounded by; *Workforce Planning and Analytics* as detailed below in **Fig. 3**.
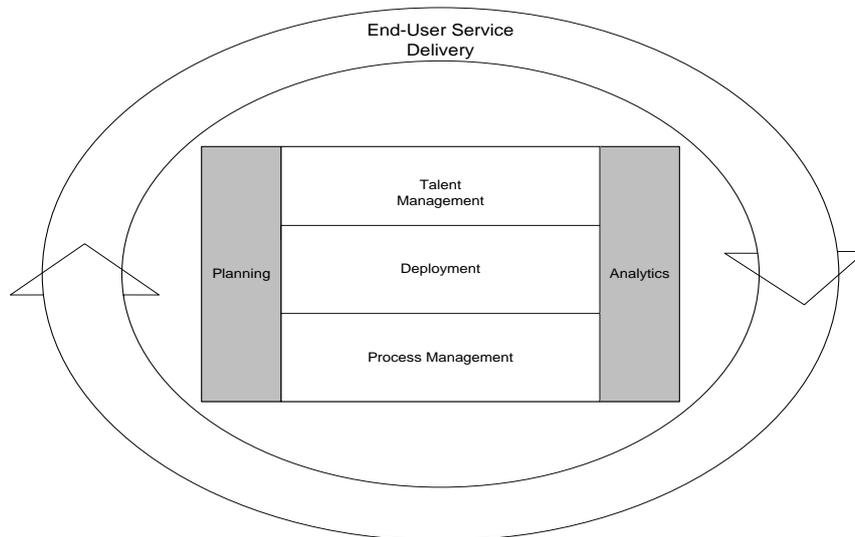

Fig. 3. SAP ERP Human Capital Management (HCM) [8]

2.4   Labor Requisition

The *labor requisition event* is defined by Dunn et al. [7] as the identification of a need for labor. Supervisors are usually responsible for determining this need through monitoring either one or all of enterprise growth (or the lack of), production plans, sales forecasts, employee turnover and other indications of labor requirements.

The *labor requisition event* can be aligned with the recruiting process within *Talent Management* in SAP HCM. Through our REA analysis of SAP HCM we have gone a step further than Dunn et al. [7] and identified four further (sub) events within the main *labor requisition event,* these four (sub) events are; *requisition*, *advertisement*,

application and *hire (*detailed in **Fig. 4** below). For each independent box (Resource, Event and Agent) the corresponding SAP table has been identified and is shown in brackets. The Resources, Events and relationships which are shaded in grey have been found to be non-REA compliant and will be discussed below, together with the other REA entities which were identified.
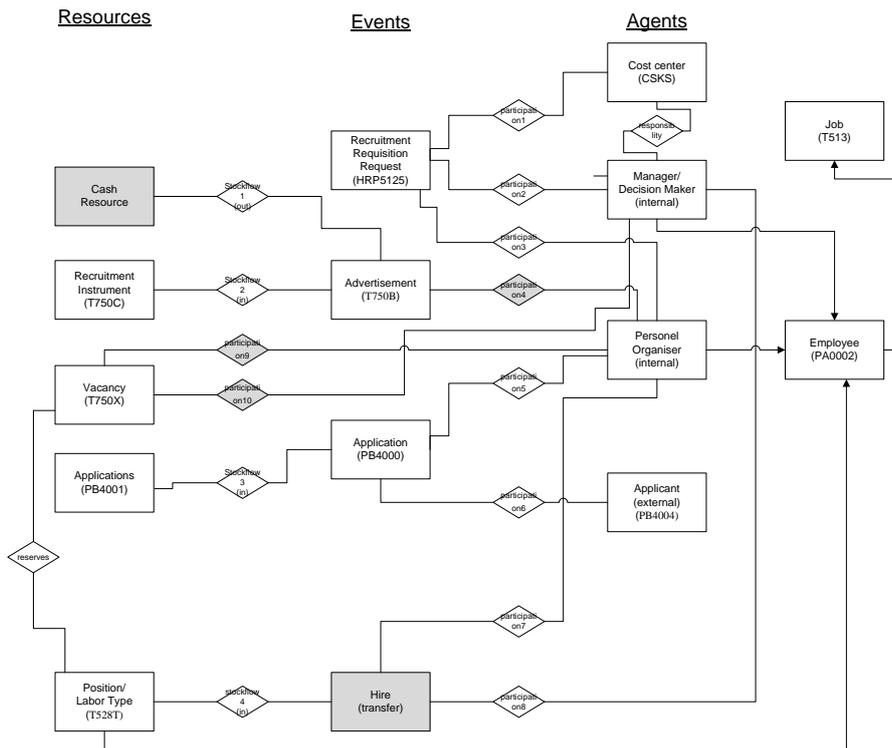
Fig. 4. Labor Requisition

REA entities.

Dunn et al. [7] state that in a valid REA design, each Resource, Event or Agent entity can be found stored within a separate database table. Using this criteria we have produced the results detailed in the Tab. 1-5 which show that we have; (i) identified many more REA entities than those defined by Dunn et al. [7], together with numerous relationships, (ii) that the tables for all the entities (except for *cash resource* and *hire event*) could be adequately accounted for within the (SAP) REA data model. The new entities discovered are detailed below;

(sub) Events.

Events are defined as 'a class of phenomena which reflect changes in scarce means [economic resources] resulting from production, exchange, consumption, and

distribution', Yu and Yu quoted by McCarthy [6], the following REA (sub) events were identified as detailed in Tab. 1 below.

Table 1. Labor Requisition Events

Event	Description	REA compliant	Comments
Recruitment Request	a request from within the organization for new personnel	yes	
Advertisement	placing of an advertisement for a new position	no	Value of PCOST stored only in this table and not in a cash resource table
Application	the receipt of an application from an applicant	yes	
Hire	the point at which an applicant becomes a new employee	no	No separate table for this event, data transferred instead from application directly to employee

Resources.

McCarthy [6] originally defined a resource as equivalent to an asset in accounting terms and subsequently a resource was further defined by Dunn et al. [7] as something with or without substance that are provided or used (consumed) during an organizations business activities thus the following resources were identified in the labor requisition event as detailed below in Tab. 2.

Table 2. Labor Requisition Resources

Resource	REA compliant	Comments
Cash	no	No table found for this resource
Recruitment Instrument	yes	
Vacancy	yes	
Position/labor type	yes	
Applications	yes	

Agents.

McCarthy [6] defined agents as persons or agencies that participate in economic events or are responsible for subordinates that participate in these events. The following agents were identified in the labor requisition event as detailed below in Tab. 3.

Table 3. Labor Requisition Agents

Agent	REA compliant	Internal/External	Comments
Cost centre	Yes	Internal	
Manager/decision maker	Yes	Internal	
Personnel organiser	Yes	Internal	
Applicant	Yes	External	

Relationships.

The following relationships were identified in the labor requisition event as detailed below in Tab. 4. The table details each relationship together with the corresponding Resource/Event/Agent which the relationships connect.

Table 4. Labor Requisition Relationships

Relationship	REA compliant	Direction	From	Too	Comment
Participation1	yes		Recruitment Request	Cost centre	

Participation2	yes		Recruitment Request	Manager/decision maker	
Participation3	yes		Recruitment Request	Personnel organiser	
Participation4	no		Advertisement	Personnel organiser	No entry for personnel organizer found in the advertisement table
Participation5	yes		Application	Personnel organiser	
Participation6	yes		Application	Applicant	
Participation7	yes		Hire	Personnel organiser	
Participation8	yes		Hire	Manager/decision maker	
Participation9	no		Vacancy	Personnel organiser	Agent found in the resource table NOT in the event table
Participation10	no		Vacancy	Manager/decision maker	Agent found in the resource table NOT in the event table
Stock-flow1	no	out	Cash	Advertisement	Cash resource not defined correctly
Stock-flow2	yes	in	Recruitment Instrument	Advertisement	
Stock-flow3	yes	in	Applications	Application	
Stock-flow4	no	in	Position/labor type	Hire	Hire not defined correctly, Historical data will be lost
Responsibility	yes		Cost centre	Manager/decision maker	
Reserves	yes		Vacancy	Position/Labor type	

Hire Event .

Duality.
A known problem was encountered when modelling the *hire event* with respect to the duality relationship, since the REA ontology fails to explicitly specify whether the duality relationship should be seen as a property of the type level (relevant for the

modelling phase) or of the instance level (of a running system) [9]. Since if the 'conceptual modelling support' function was to be used which states that, when duality is used as the criterion of a valid model then; 'all types of a valid model must be coupled in duality relationships with other events' [9]. In the case of the Hire Event we have interpreted this duality relationship as belonging to the *instance level* of a running system, which means that there is no way to identify which named event type this particular *hire event* should be paired with. There was no evidence found within the SAP system of any event type which could correspond with the duality properties of the *hire event*. As observed by Borch and Stefansen [9] both possibilities are acceptable and they suggest that 'it is possible for the user of the ontology to make his or her own interpretation'. Our interpretation of this event, that it is belonging to the *instance level*, corresponds with the fact that the REA model was defined given the SAP implementation and not that the implementation followed an REA design.

Data storage.
As previously stated Dunn et al. [7] assert that in a valid REA design, each Resource, Event or Agent entity can be found stored within a separate database table. However within SAP HCM the *hire event* is not stored within a unique table, instead when this event (an applicant is hired) occurs the information about the applicant is moved from the applicant table directly to the employee table. Thus data is lost at this point since it is not possible to trace back directly to historical details of the event. There are of course practical implications which must be to be taken into account when a system is implemented, such as the necessary storage requirements when each and every event is stored. O'Leary [10] identifies this same issue and states that 'an events accounting system is a theoretical ideal which realistically would never be implemented'. He then draws the same conclusion that unless storage became costless and abstracting detail was 'painless', there would never be full event histories. The assumption can therefore be made that the designers at SAP made the decision to reduce data storage requirements by storing this event and the relevant data in this way.

Cash Resource.
For the business process *labor requisition*, the storage of *cash resource* does not follow REA principles, since the value of placing an advert (a cash resource) is stored within the *Advertisement Event* in the SAP table T750B in the column PCOST. However, this value does not find duality within the system, since it does not at any point within the business processing get transferred to a *Cash Resource* table or subsequently to a *general ledger* (resource) table. The value PCOST is used later by a SAP reporting process to determine how many applicants are received through a specific advert and thus determine a cost per advert per application. But at no point is the value PCOST booked against any cash accounts. There is no stock-flow in, in terms of an advert that has been placed, but no stock-flow out in terms of a *cash resource*, the payment for the advert which has been placed. Therefore in the processing of *labor requisition*, the SAP system does not conform with REA theory, which leads to information been lost or repeated (at a later date) in the database. It is

our assumption that this value (PCOST – cost of advertising) must at a later date be deducted from the general accounts ledger, however no evidence could be found to confirm this assumption.

Vacancy Resource.

The *vacancy resource* is stored within the SAP table T750X. The table contains foreign keys to the HR personnel organizer (participation9) responsible for this vacancy and the line manager (participation10) to which this vacancy has been assigned. The table also contains a foreign key (reserves relationship) to the position/labor type table that provides details of the position which is vacant. The structure of this table does not conform directly with REA theory, since the agents (involved in the event) should not be assigned directly to a resource (table) but should in fact be assigned to the event taking place [7].

Relationship participation4.

The advertisement (event) table does not contain the details of the personnel organizer responsible for this advert, shown in **Fig. 4.** Labor Requisition as relationship participation4. This does not conform to REA theory, which states that each agent which participates or is responsible for an economic event should be identified.

2.5   REA compliance

From the REA entities identified in SAP HCM and detailed in Tab. 1, we have produced the following table Tab. 5, which shows what percentage of the REA entities identified can be defined as been REA compliant.

Table 5. REA compliance

Entity	Number found	REA compliant	Compliance
Resources	5	4	80%
Events	4	2	50%
Agents	4	4	100%
Relationships	15	11	73%

3   Summary and Outlook

When examining the results as detailed in Tab. 1-4 and more specifically at the REA compliance of each of the entities discovered Tab. 5, we can concur with the results of O'Leary [10], in that we have underpinned how SAP's business processes (in SAP

HCM) can be effectively modeled using REA techniques. However we go further in two significant areas;

The results have shown (in detail) how REA can be used for modelling a business process; Human Resources. The detailed evidence shows one database table (-and several smaller anomalies) where SAP is not REA compliant, and resulting from this non-compliance, also shown how data is lost or repeated in the SAP database.

We have also confirmed a further statement from O'Leary [10] that 'SAP was found to be consistent with REA in its database, semantic, and structure orientations. However, there were some implementation compromises in the structuring and semantic orientation of the SAP data model'.

With regards to modelling business processes such as HR, O'Leary [10] makes the statement;

'For many real-world settings, REA is underspecified. For example, if we want to know how a human-resources process works, REA provides no direct insights. However, given a human resources model or system, we can map it to REA to try to understand it better or we can build a system using REA as a guide to the underlying data model, etc.'

This statement is reiterated by Geerts and McCarthy [11], however in section 2 we have shown how a business process in SAP HCM can in fact be adequately modeled using REA techniques and thus be subsequently represented in REA templates.

It is unlikely that SAP was implemented following a generic template model, since SAP has been implemented over a successive period of development over many years and thus is likely to contain many artifacts from the past such as the classical general ledger system of accounting. Moreover SAP was clearly not originally implemented following an REA paradigm [10], so it also clear that the differences between REA and SAP can be interpreted as modelling compromises from an REA perspective. The same conclusion is made by Hessellund [12], who then suggests that this difference in interpretation will provide (a positive) feedback to the ontology development process and (can) be used as inspiration for further extensions of the core ontology.

The REA designs detailed by Dunn et al. [7] were a useful starting point, from which we have shown how REA can be used as a useful tool that can be used to increase the system design and understanding of the business process implementation. Through using REA analysis we have shown how our theoretical REA designs can be mapped directly to a real world (SAP) implementation.

A recognized limitation to REA modelling was encountered when analyzing SAP HCM, in that the REA model identifies only a structural view of the system, with the result that all behavioral aspects of the model must then be identified and documented using techniques such as data-flow diagrams [13]. The recognized solution to this problem is the use of unified modelling language (UML) for object-oriented modelling, previously identified by Booch et al. [14]. This again emphasizes the need noted by others [10, 13] for further research that will lead to a set of tools and procedures which will allow REA designs to be used for the entire development life cycle.

The data identifying the REA compliance of the REA entities discovered Tab. 5, would appear to indicate that in the critical area of defining *event* entities, SAP has

the most problems with REA compliance. Through this non-compliance with the REA ontology, we have shown how data is lost or stored again (repeated) within the SAP database. This confirms McCarthy's [6] original theory which led to REA, since he identified that using conventional data storage techniques (such as double entry), it would lead to inconsistency of data, *information gaps* and *overlaps in data* or *data spread*.

We have corroborated the findings exactly as foreseen by [10], namely that in two significant areas i.e. (i) SAP could benefit from an REA approach to business process engineering, since this would avoid data loss, and (ii) REA could benefit from an analysis of a real ERP system. Notably in this respect we have identified many more entities than those defined by Dunn et al. [7].

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