Towards Dependable Change Management and Traceability for Global Software Development

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Abstract—This paper reports on our definition of guidelines for managing global software development (GSD) that implements the specific practice - manage requirements changes - of the Capability Maturity Model Integration (CMMI) Level 2. The guidelines present a model for change management and traceability that supports the implementation of the specific CMMI Level 2 goal. Also, to support the effective management of the system engineering processes, an adaptation of the Project Management Body of Knowledge (PMBOK) process group (PG) for project lifecycle practices is provided. We introduce a cloud-based Reactive Middleware which provides services for managing GSD projects towards dependable change management and traceability.

I. INTRODUCTION

System (or software) engineering is increasingly being practised over distributed geographical locations. This practice is classified as global software development (GSD). The growth in information technology such as cloud computing enables different projects to be developed at geographically distributed sites [1]. The acceptance of the GSD process is because of its different benefits such as low cost, good productivity, access to skilled workforces and access to market [2].

However, GSD is highly dependent on requirements management to ensure that the distributed teams are meeting project requirements. Requirements management is a collaboration intensive activity, which produces and consumes numerous artefacts during a project’s lifespan. Software requirements continuously change during the software development phases and it becomes very difficult to manage these changes [1]. Developing a shared understanding and awareness of these artefacts is integral to software collaboration [3], a challenge that globally distributed teams face on a regular basis. Use of collaborative technologies and artefacts is pervasive in GSD to alleviate some of the barriers caused by distance (geographic, temporal, and cultural), and to facilitate consistency in understanding and managing requirements [4].

Also, the management of system engineering across all phases relative to meeting system requirements has been identified as the main source of software project failures [5]. According to the Chaos Report 2013 released by the Standish Group, among all the large IT application development projects in 2012, only 10% of the them were classified as successful, while 52% were identified as challenged (completed but failed to achieve project initial goals such as time, cost or quality requirement), and the rest 38% of the projects totally failed (cancelled before completion or never implemented) [5].

This however, calls for the adoption and integration of; (1) software process improvement models such as capability maturity models (e.g. CMMI [6] and ISO/IEC 15504) that focus on change management and traceability, and (2) well established management practices such as those presented by the Project Management Body of Knowledge (PMBOK) [7]. Such an approach is essential for managing software or system engineering projects in a way that does not unnecessarily burden project managers.

We report on the definition of a set of guidelines for managing GSD that implements the specific practice - manage requirements changes - of CMMI Level 2. These guidelines are facilitated with a Reactive Middleware which applies a model for change management and traceability (CM-T), that supports the implementation of the specific goal. Also, to support the effective management of the system engineering processes, an adaptation of the PMBOK process group (PG) for project lifecycle practices is provided.

We aim to answer the research question (RQ): "How can the reactive middleware guide system engineering to ensure the continual tight linkage of stakeholders’ requirements and system engineering processes?", by validating the following hypotheses; H1: Changes in system engineering requirements-related artefacts are captured and adequately propagated to all the related system engineering processes and stakeholders, and H2: It is possible to trace system development artefacts from creation and through system engineering processes.

II. REACTIVE MIDDLEWARE

The Reactive Middleware (RM) introduces a structured role-based management of system development artefacts. Role in this context is described as stakeholders’ responsibility (i.e. privilege) to system artefacts. The RM is "reactive" due to its cloud-based services for change management and traceability. This approach assigns priority to system requirements relative to their importance. Also, the approach uses six main privileges (with roles): None:- Have no access to the system artefact(s) for PAWNS, View:- Only sees the system artefact(s) for PAWNS, Modify:- Can see (view) and change the system artefact(s) for MODIFIERS, Review:- Can see and change...
System development teams should appoint team leaders who will constitute the system stakeholders or change agents. The privileges (i.e., none, view, modify, review, own) of system stakeholders or change agents determine the access privileges to system artefacts. On the other hand, conflicts arising from changes to low-priority sets of requirements are resolved locally, led by the local team leader. When changes affect the high-priority set of requirements, appropriate local team leaders must lead the change request review process (i.e., involving the CM-T model) of the system artefacts. All system artefacts should be saved in a shared artefacts repository. Changes made to any system artefacts must be traceable to manage its impact on related/linked requirements or artefacts. All other artefacts can either be deleted or reinstated, to facilitate traceability.

The RM is composed of the Publish/Subscribe system (PSS) and the Artefacts Monitoring system (AMS). The PSS facilitates the subscription of system stakeholders to prioritised artefacts, which they will initiate change requests or will receive change notifications. Also, the AMS is responsible for monitoring the relevant artefacts for changes, and then triggers the PSS to notify appropriate stakeholders or change agents. The RM interacts with the system stakeholders, System Engineering Tools, and a Shared Artefacts Repository. From Figure 1, the GSD Team Members have the flexibility to adopt any type of software development life-cycle (SDLC) approach (e.g., waterfall, agile, spiral, etc.) that suits their development style (i.e., Step 1). Then following the prescribed management guidelines (see Table I), featured by the Reactive Middleware, the GSD Team Members manage the development process with the PMBOK process group for system engineering life-cycle (i.e., Step 2). When there are change requests that are related to the high-priority requirements, the GSD change managers apply the CM-T process model (see Figure 2) to either approve, note (i.e., to be applicable in the future) or disapprove the request (i.e., Step 3*). This CM-T model takes into consideration the traceability of the change agents (i.e., system stakeholders, artefacts and tools) involved in the change request. System engineering tools form an important change agent in the development process (i.e., Step 4).

III. Conclusions

We report on our work which defines a set of management guidelines for GSD projects. We introduce a Reactive Middleware that applies a defined change management and traceability process model, and an adapted PMBOK quality process management approach to GSD. The CM-T process model is evaluated using expert feedback processes, while the management guidelines are evaluated using an airlock control system case study. We then answer the research question (RQ), by validating the hypotheses (H1 and H2) presented earlier.

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