**Exploring the association between the development practice and the project context**

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**ABSTRACT**

In this paper, we bablabla

**Keywords**

Development practice, project context, association, grounded theory, embedded software development

# INTRODUCTION

Best practices in software engineering have always been pursued by practitioners and researchers to improve the software productivity and quality. Nowadays, a large quantity of literatures tried to recommend best practices for the industrial software development practices, by analyzing some successful projects, introducing the transparency and collaborative characters of open source software, optimizing a specific development step of practices, etc. However, people sometimes found it hard to reproduce the achievement of the projects or the development steps mentioned in the existing literatures, even if the researches are well known and widely accepted.

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*Conference’10*, Month 1–2, 2010, City, State, Country.

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DOI: http://dx.doi.org/10.1145/12345.67890

In the industrial software development practices, practitioners are involved in different projects. As we all know, these projects have different levels of software productivity and quality. They are producing products in all kinds of industrial fields, applying various development methods and development processes. And their development practices vary in some way. But what makes these differences, why each project adopts the specific development practice and is there anything that the development practice is associated with. Practitioners might not be aware of the answers to these questions, neither are the researchers. To the best of our knowledge, there is not existing research studying the questions mentioned above. We believe that to study these questions is significant in two aspects. On one hand, it could help practitioners to understand the difference between projects and the cause of different development practices, and to search for more suitable practices for the projects. On the other hand, it could offer some inspirations for researchers about whether the best practices they study could be applied to industrial software development or what details should they study to make sure that the best practices could be applied to industrial software development.

In this paper, we reported a study of exploring the association between the development practices and the project context in some specific industrial fields. Our study mainly oriented to the embedded software product field of Siemens. We conducted interviews with three project managers of different embedded software projects from Siemens, discussing about the context and detailed development process of their projects. We followed the Grounded Theory approach to analyze the interview data and identified two main categories, Development Practice and project context. Development Practice is based on the key concepts, tool use, test method and step boundary, while Projects Context is based on project maturity, cross-regional collaboration, product field, scheduled development mode and length of development steps. Then the categories and concepts formed three statements about the association between development practice and project context: 1. the dependence on tools in the development process is related to the maturity of the project and whether they cooperate with distributed teams; 2. the test method, mainly the cost and test strength, is affected by various project context, mainly the development method and the product fields; and 3. the stipulations of different projects about the boundary between adjacent steps is related to the maturity of the project and the length of development steps the project involves in. Finally, we made a discussion about (innovation).

The study presented here is one step towards a larger goal. We believe that the theories we found can benefit two kinds of people. For practitioners in embedded software development field, they can analyze the contexts of their projects, refer to the development practices of the relevant projects of Siemens, and then search for some specific practices suitable for their projects or make some optimization and breakthrough in some steps to improve the whole development process. For researchers trying to find the best practice for industrial software development, the study could offer them some inspiration. If they try to make the success of a particular project or a specific development step reproducible on other projects, they might need to consider the association between the context and the development practice of the projects. And we appeal to study what granularity about the project context we should achieve, is enough to reduce the difference of different projects when reproducing the best practice.

The rest of the paper is organized as follows. Following this section, we provide the background about research of Best Practice and the research question of our work. In Section 3, we present the details of our study design such as interview procedure and the results of the qualitative analysis. Findings based on the grounded theory are explained Section 4. More discussion about the innovation is addressed in section 5. Finally, we mention future work and conclude in Section 6.

# BACKGROUND

(Background about the research of best practice- open source practice, GSD, improve specific steps, hard to be reproduced.)

Our study was driven by the following research question:

**RQ**: how are development practices associated with the project context in some specific industrial fields.

# STUDY DESIGN

(Introduction to Siemens) Since Siemens is successful in embedded software development area, we contacted with 3 Chinese departments/branches of Siemens, and then conducted in-depth, semi-structured interviews with the project managers from 3 embedded software development projects. The interviews polled interviewees about the detailed project context and the specific development process they follow. We pointed project managers to attend the interviews because they are familiar with the projects and can offer us the most exact and detailed information of the interview questions. To answer the research question, we analyze the interview data using the Grounded Theory approach. In the following sections, we would introduce the detail interview procedure, including the interview questions and the responses of the interviewees, and the result of our qualitative analysis in the following sub-sections.

## Interview procedure

We selected 3 embedded software development projects from different Chinese departments/branches of Siemens and then invited the project managers to attend the one-hour long and semi-structured interviews. All interviews were recorded and transcribed to facilitate iterative analysis. The first PM is in charge of a project (AUC) developing the automatic driven embedded software for process instruments, such as the transmitter and liquid level indicator. The second one is leading the project (BT) for building technology, mainly developing the embedded automatic control software for fire control, air conditioning control, etc. The third one is managing the digital factory machine control project (DFMC), developing digital control parts of industrial machines, such as lathes. Moreover, they all have more than 10 years of work experience in Siemens.

To focus our interview questions, we started all interviews by asking the interviewee to introduce the basic information of his/her projects, including history, initial environment, application fields, scale, organizational structure, etc. We then asked the interviewee to describe his/her responsibilities, their typical workflow, the development process they follow and the development management tool they use. We guided the interviewees to provide details about how do each specific process carry on, how are different steps connected, how are different teams communicated, and their usage of the historical data, etc. We refined questions after each interview based mainly on the analysis results of the previous interviews, as well as the existing literature. The analysis provides us with focus areas that we could address further in the next interview.

The project managers of the three projects showed us an overview of these projects, which gave us some basic understanding about the projects, and benefited for the following analysis.

In Table 1 we summarized some basic information of the projects we interviewed. We can see that all the projects are developing embedded software, but for different products and markets, and have different projects ages. They all work with global distributed teams, but the relationship with their collaborative teams vary. Therefore, we believe that the projects we chose contain several different characters, and the theories we found from these projects could offer some references for the same kind of embedded software development projects.

Then in Figure 1, we gave out the general development process of the projects interviewed. They all follow the same development process, but this each step of the process they would have some customization according to their characters and the realities of situations.

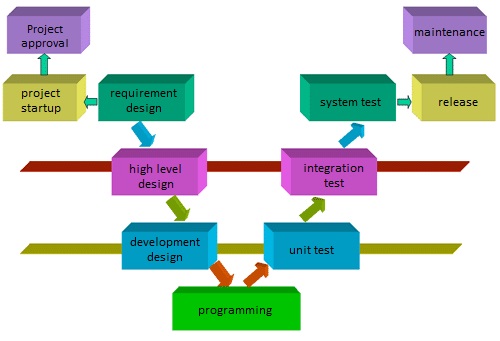


Figure 1 the general development process of projects

## Result of qualitative analysis

We based our study on the interview responses of the 3 project managers from 3 embedded software development project of Siemens. After the interviews done, we use the Grounded Theory approach in processing interview data. We transcribed the recorded interviews and open coded them. The code system developed iteratively, by coding, discussing codes, combining and splitting codes, and writing memos about more abstract phenomena as they emerged. Next, we engaged in axial coding our codes in order to find higher level conceptual themes, and we identified concepts that stood out, which would help us to build the answer to our research question. In the last phase, we grouped concepts into two main categories, Development Practice and Project Context, which would be the main elements to form our grounded theory.

In detail, Development Practice is based on the key concepts tool use, test method, and step boundary, while Projects Context is based on project maturity, cross-regional collaboration, product field, scheduled development mode and length of development steps. In table 2, we presented the detailed meaning of the concepts.

# Findings

Based on the categories and concepts identified through the Grounded Theory approach, we formed three statements about the association between project context and development practice. In this section, we presented our findings.

Although, the three projects are all in embedded software development field, but we still found many differences both in their project context, and in their development practices. We found the significant differences of the context of the three projects are: 1. the history and the team size of the projects; 2. the length of the process steps the project involves in; 3. the frequency of cooperating with other teams; and 4. the coupling of the cooperating teams’ work. And the significant differences of the development practice are: 1. the use of tools in the development process; 2. the test method, including the cost, strength, etc.; and 3. the clarity of the boundary between adjacent steps. As we analyzing the interview data using GT approach, we found the causes for these differences and the association of project context and development practice focus on 3 underlying themes:*The dependence on tools* in the development process is related to *the maturity of the project* and whether they *cooperate with distributed teams*, *the test method, mainly the cost and test strength,* is affected by various *project context*, mainly *the development method* and *the product fields*,and the stipulations of different projects about *the boundary between adjacent steps* is related to the maturity of the project and the length of development steps the project involves in.

1. *The dependence of tools in the development process*

The dependence on tools in the development process is related to the maturity of the project and whether they cooperate with cross-regional teams.

As we know, operational support tools such as issue tracking system (ITS), version control system (VCS), mail system, forum, etc., have been extensively adopted by software projects. But what tools developers actually used in the development practices and how developers used these tools vary from projects to projects, just like the projects we interviewed.

In the interviews, the project AUC reported that their project is quite mature, every steps in the process are quite stable, and they would strictly follow the use of tool. The German team would define the input and output of the software part of the product in the form of user-story in the Team Foundation Server (TFS, one kind of ITS), and then the Chinese team would turn to the TFS to get the requirement. Developers would develop the code in the Clear Case (one kind of VCS), report and resolve all the relative issues on TFS, and after all things done, they would submit the periodic code version by the shared Clear Case server to the German team to make the integration. During the development process, they would use internal communication tools or mail system to collaborate with the distributed teams. The PM of AUC stated that use of tool would push them to follow the existing mature process to develop, which would ensure all things are done on schedule. Besides, because they need to cooperate with the cross-regional teams frequently, using these tools could greatly improve the efficiency in the handover of requirement and code, discussion on issues, progress of tasks, distribution of tasks, etc.

And the project DFMC is migrated from the German team, but faces to a new market, China. The previous project in Germany has decades of history, so DFMC just follow the previous mature development process to develop products for China market. The PM also reported that they would strictly follow the use of tool and would cooperate with the cross-regional teams through these tools.

On the contrary, the BT project is new relatively and still in exploration. The PM of BT reported that they don’t depend on tools totally. When discussing issues, sometimes they would just fix the issues in private, instead of reach to the ITS. And as for the handover of requirement or code, they would also complete it by discussing or distributing directly face to face. The PM stated that they are work in the same floor, it is quite convenient to do so. Besides, they would just compress the code versions and copy them to the test persons for testing directly. And it is because the test persons have no access to the code repository.

We can see that mature projects would follow the use of tool more strictly in general, because they have formed a pattern to organize the development. To follow the use of tool is to follow the practice pattern and thus to keep a high productivity and product quality. In addition, projects that involve cross-regional collaboration should depend on the tools to improve their cooperation efficiency, while those independent relatively projects would have much more cooperation methods except these tools.

1. *The test method adopted by the projects*

The test method, mainly the cost and test strength, is affected by the development mode and the product fields.

Software test is an important step of the development process, to ensure the code is out of both logical issues and functional issues. The test step usually includes three phase, unit test, integrate test and system test. In practice, different projects would adopt different test methods, and their requirements for each test phase vary as well. The projects we interviewed showed different opinions towards the unit test.

The PM of AUC reported that their product, process instrument, is of high requirement of accuracy, and would be used in many safety areas. There is a standard enacted by international organizations called IEC61508 detecting if the product fits the safety standards, which would check the test coverages of some product’s components. So the AUC spends a lot of effort to strengthen the unit test and makes sure that the test coverages of some important components are 100%. Besides, the AUC adopts agile development mode. At each development cycle, they would receive several feature requirements from the German team and then conduct iterative development. Their ratio of the number of developer and tester is 1:1 and the PM reported that the time they spend on testing is much more than that spend on developing.

However, things are much different for the other two projects. The PM of BT reported that they don’t care much about the unit test and prefer to do the integration as soon as possible. They thought the unit test doesn’t worth the cost they spent. And they don’t pursue 100% unit test coverage. So as the project DFMC. The PM of DFMC stated that the test coverage is too hard to pursue for the software part, and the amount of bugs they found in the unit test phase is very few.

We found that the test methods, including its cost, strictness and test coverage, adopted by projects vary a lot. From the interviewed projects, we can see the product application field would affect the test method a project adopts. If the product application field has a high requirement of accuracy, or the product need to fit a strict safety standard, the test method of the project would be much stricter, and the cost they would like to spend on it would be much more. Besides, the test method is also related to the development mode. Different development modes would be suit for different test methods.

1. *The demarcation between adjacent steps*

The stipulations of different projects about the boundary between adjacent steps is related to the maturity of the project and the length of development steps the project involves.

A development process contains many development steps, as we showed in Figure 1. But the boundary between the adjacent steps would not always be clear.

The PM of project BT reported that they are in charge of the whole development process, from project approval to production and maintenance. The process is so complex and it contains too much relative aspects. What’s more, the project is still in exploration. Therefore, it is hard to define the boundary of each step very clearly, sometimes they would overlap, and sometimes the current step would return to the last step. For example, firstly, the requirement is designed and developers start to program. Then they find that one feature is too hard to realize or the feature is not necessary at all. The requirement design step would redesign the requirement while the programing step is still working. The two steps would both be running and have influence to each other.

While the AUC project is quite different. The Chinese team just take charge of several steps of the development process. Compared with the BT, the scope of their work is much smaller. The PM stated that what they should do is to get the final version of requirement from the Germen team and then realize it in the form of code and ensure the 100% test coverage. After hand over the final version of code to the Germen team, their job during that cycle is done. The boundaries of these steps they involved is quite clear and they could conduct the steps just one by one.

We can see that the stipulations of different projects about the clarity of the boundary between adjacent steps vary. It is related to the maturity of the projects and the length of the steps the projects involves in. The mature projects plan better in every development steps, and the boundary of the adjacent step would tend to be clearer. While the projects that involve in too much steps of the development process, would tend to overlap some steps. In fact, these two kinds of projects have both strengths and weaknesses, which still needs some discussions.

# DISCUSIONS

Throughout the previous sections we reported the difference about the development practices of the three projects. By analyzing the interview data, we found and summarized some specific contexts of projects that cause the difference of development practice. We analyzed how the contexts of the Siemens’ embedded software projects are associated to their development practices.

In the interview, we found that the maturity of project is an important element that would associate with the development practice. In other way, we can say that the development practice evolves as the maturity of project increasing. Generally, the mature projects tend to inherit the past development practice and follow the past development process, while the immature projects are still in exploration, they would keep trying and adjusting, and would finally find some practices that is suitable for the projects. Take the projects we interview as examples, the project AUC has formed a mature development process to keep high productivity and software quality. The Chinese team would just follow the process and complete the software part according to the requirement of German team. In some way, it lacks of innovation. Without doubt, we should inherit the mature and successful practice that formed in the past, but we still need innovation to bring more creativity and efficiency to the development practice. Innovation is also an important element in software development.

There are many literatures about innovation in the research field of organization, focusing on mainly two aspects. One is about the benefit of innovation for both organization and management. The other is how to create a culture of innovation in the organization.

# CONCLUSION AND FUTURE WORK

Nowadays, researchers are trying to introduce some best practices to industrial software development to pursue higher software productivity and quality. However, the industrial software projects have different development practices, and practitioners found it hard to reproduce the success of other projects or development process. In this paper, we reported a study to explore the association between development practice and project context in the embedded software product field of Siemens. We conducted interviews with 3 project managers and used grounded theory to analyze the interview data. Finally, we found that there does exist association between development practice and project context in these projects, shown in 1. the dependence on tools in the development process is related to the maturity of the project and whether they cooperate with distributed teams; 2. the test method, mainly the cost and test strength, is affected by various project context, mainly the development method and the product fields; and 3. the stipulations of different projects about the boundary between adjacent steps is related to the maturity of the project and the length of development steps the project involves in.

The study presented here is one step towards a larger goal. We believe our study can be helpful for two kinds of people. On one hand, it can help practitioners in embedded software development field to search for some specific practices suitable for their projects or make some optimization and breakthrough in some steps to improve the whole development process, according to the context of his/her own project. On the other hand, for researchers trying to find the best practice for industrial software development, the study could offer them some inspiration about whether the best practices they study could be applied to industrial software development or what details of project context should they offer to make sure that the best practices could be applied to industrial software development.

So far, our finding only oriented to the embedded software development field of Siemens. In the future, we would explore other industrial software development fields and build more general themes about the association between development practice and project context. We would also conduct survey to verify our findings. Besides, we would try to give some insights about which project context we should consider, when adopting other projects’ development practices.

# ACKNOWLEDGMENTS

Our thanks to ACM SIGCHI for allowing us to modify templates they had developed.

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Table the basic information of the projects

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Project ID** | **Department/branches** | **product** | **Product market** | **team’s scale** | **Collaborative team distribution** | **Main relationship between distributed teams** |
| AUC | PI House (the automatic control department of Siemens’s research technology center) | the automatic driven embedded software for process instruments, such as the transmitter and liquid level indicator | global | 13 | China, Germany, Canada, India | German team defines the input and output, Chinese team implements the embedded software part. |
| BT | BSCE (the development and production center for building technology) | the embedded automatic control software for fire control, air conditioning control, etc. | Chinese | 30-40 | China, America, Switzerland | They are at the same level, implement the whole development process facing different markets. American and Switzerland team have more mature technology. |
| DFMC | SNC (the digital factory machine control business union of Siemens) | The embedded digital control parts of some industrial machines, such as lathes. | global | 15 | China, Germany, America | Chinese team is in charge of the whole process. German and American team help develop different components of the software. |

Table the categories and concepts identified by Grounded Theory

|  |  |  |
| --- | --- | --- |
| **category** | **concept** | **Meaning of concepts** |
| Development practices | Tool use | How does they depend on development management tool in the development process |
| Test method | The strength of the unit test and the cost they put on test |
| Step boundary | The clarity of the boundary between the adjacent development steps |
| Project contexts | Project maturity | The maturity of the project, considering the project history and team age, etc. |
| Cross-regional collaboration | Whether the project need to collaborate with cross-regional teams frequently |
| Product field | The application field of the product that the project develops |
| Scheduled development mode | The development mode that the project schedules to adopt at the beginning |
| Length of development steps | The length of the development steps that the projects involves in. |