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AUT UNIVERSITY COMPUTING + MATHEMATICAL SCIENCES

A Case Study of the zKVM Project from

Big Iron

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1. Abstract

This report is a case study on the zKVM project running inside the world biggest software and servicing company Big Iron. With a thorough interview with one of the technical leader from Big Iron's Beijing lab, a general development process of the zKVM project is studied. Both organizational and development methods, tools and their practices are revealed in this report. Agile methodology has widely applied inside the organization, but not all projects have adopted it. The hardware group STG basically is still following the waterfall development model, which has been proved to be successful with numerous successful projects.

After a close look at the development model of the zKVM project, a few popular Agile practices were identified in their development process. So strictly speaking, the zKVM project is running a hybrid waterfall-agile methodology.

At last, a key challenge to the project is identified with the employee turnover, which may damage the team competency and impact the release progress. A small recommendation is given to mitigate this risk: Money Talks!

2. Introduction

As a saying goes “there is more than one way to skin a cat”, in software development world, two methods being Agile and Waterfall are the dominant ones, which are widely used by almost all software companies. The choice of Agile or Waterfall often causes endless debates in all kinds of IT meetings. An online survey of 601 software developers and IT professionals in 2015 (Jeremiah) has shown that Agile has become the norm in software development organizations. Two thirds (403) of the organizations have adopted agile methodology, of which 37% are large organisations with more than 1000 employees.

Big Iron as one of the world’s largest software company has started to adopt the Agile methodology early in 2007 (Kanaracus). Back then 25% of the projects were employing some manner of Agile. In 2008, Big Iron has already become a pioneer of Agile in IT world and actively providing transforming its Rational software to better support Agile. By 2012, Big Iron proclaimed that it has saved $300 million dollars with help of Agile (Poole).

This case study is conducted on the basis upon the interview with one of Big Iron’s technical experts from the System Technology Group lab located in Beijing.

Section 3 introduces a little background of the company and the project that the expert is working for; section 4 summaries both the organizational and development methods, tools and practices in Big Iron; section 5 tries to make a recommendation for the challenges found in the project.

3. Background

Big Iron is the world’s largest technology and consulting company in the world, which has more than 100 years of history. One of the core businesses of Big Iron is to provide the market exclusive high-performance mainframe computer, used widely by banks, corporations and government agencies who requires high level RAS – reliability, availability and serviceability. The mainframe computers have become the most important cornerstones of almost every big bank around the world.

With the advent of cloud computing, Big Iron realised that supporting cloud computing in the mainframe is more demanding than before to more efficiently manage the hardware resources with the help of virtualization. Although Big Iron has already supports the virtualization technology starting from 1972 on the hypervisor program called VM/370, the integration with the latest cloud solutions like the Openstack is far behind the other competitors, such as the new star who was inspired by Big Iron – VMWare. The latest

version of VM hypervisor in market is named as zVM, versioned 6.3. The high performance hypervisor software is written wholly in an assembly language and an in house proprietary language called PL/X. With more requirements come in, and few experts in the programming languages remain in Big Iron, the company recognized that continue supporting zVM shall be a big burden of the corporation, and introducing the open source power may greatly reduce the development pressure on Big Iron, and better incorporate the mainframe virtualization technology with contemporary cloud solutions.

KVM (Kernel-based Virtual Machine) is a new virtualization technology for the open source operating system Linux, which makes Linux OS become a new hypervisor for x86 platforms initially. As Linux is a cross platform operating system, adding Mainframe support on the KVM module naturally makes a new hypervisor for the mainframe computers.

With a successful prototype of zKVM for mainframe computer, Big Iron made a historic decision to create brand new Hypervisor software based on KVM technology to better support the customers to compete in the cloud era. A new product line with around 100 developers and testers are formed around 2013.

4. Case Presentation

4.1. Organizational Methods, Tools and Practices

When asked what the software development methodology being used in the zKVM project, the expert gave a definite answer: “waterfall”, which is so surprisingly and contrary to our expectation of Big Iron.

Big Iron has 2 big groups in organization structure: Software Group and System Technology Group (normally thought of as Hardware Group). The expert just comes from the STG group, in which Agile is not as popular as the Software Group. The zKVM project development process could simply demonstrated as the traditional Figure 1:

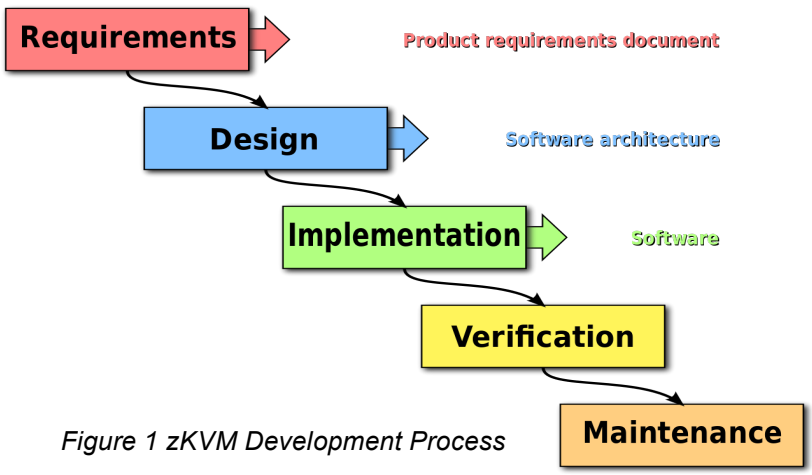

Figure 1 zKVM Development Process

4.1.1. Roles of the Team

In total, there are about 100 employees involved in this project, which consists of:

- RCB (Requirement Control Board) – a group of people including the client representatives, marketing representatives, sponsors and Distinguished Engineers who are familiar with certain fields. This board discusses and determines the requirements for the zKVM project, which could best fit the market demands.
- CCB (Change Control Board) – logically another group of people that follow the market trend and recognise the customer's requirements change, and make decisions if any change to the product requirements backlog should be made. In the zKVM project, CCB and RCB are the same group of people.
- Program Director – is the highest director of this project, who is reporting to the product sponsors.
- Architects – one lead architect covering all the zLinux related products, and one zKVM specific architect covering zKVM only; the 2 architects reports to Program Director and provides an overall solution to the RCB board.
- Developers – 4 teams of developers distributed in four regions globally: Germany, US, China and Russia. They are responsible to deliver the codes for zKVM only.
- Testers – similar to development teams, there are 2 teams distributed in 2 countries: Germany and India. They are responsible to take the feature specification documents from development teams, write and execute the test cases.
- Development/Test Manager, each team is managed by a manager, who helps gatekeeping the project progress.
- Team Leads – each development and test team has one or more team leads who are focusing on one area.

4.1.2. Requirements Management

Requirements are categorized into 2 groups for different users and purposes. The requirements discussed in scope of RRB and CCB are confidential to only a small range of relevant people, excluding the developers and testers, even the Architects. These are high-level requirements normally saved and managed in a central protected Lotus Notes database. All RCB and CCB board members update and prioritise them at the Concept stage of the project.

Once the sponsors approve the project, project came into initialization stage, then the requirements with prioritization are revealed to project architects. Architects then evaluate the requirements and suggest which features are viable depending on all kinds of factors.

At last, the final requirements agreed by the architects are broken down into fine grained Line Items, which are accessible to all developers and testers. All developers and testers then evaluate if they can complete these Line Items by the release dates.

Once all developers and testers are consent with the Line Items based on their sizing, the project comes into Implementation stage; the requirements are then documented and managed in the RTC (Rational Team Concert) platform.

4.1.3. Development Mode and Pace

Each Line Item is assigned to one developer, who is responsible to develop and deliver the code. The sizing is evaluated by team lead, and a delivery date is discussed and agreed with the owner. Every week, a status of the Line Item is reported to the team manager, who will in turn reports to second line manager, in turn to the highest director (maybe biweekly or monthly). Team lead is closely working with the owner every day, so that any problem in the progress of development is monitored and dealt with timely to meet the dead line of the delivery.

A meeting inside the team is hosted by team lead every few days depending on project progress and the problems. This resembles the Agile scrum daily stand up meeting, but differs in frequency and duration. Normally the meeting continues from 30 minutes to 60 minutes, discussing and sharing the technical issues.

A weekly meeting from all development teams leaders is arranged at a best-suited timeslot for 4 region team leads. Only 4 team leads join this meeting and communicate with each team's status, issues and progress. This is analogous to Scrum of scrum meetings.

The test teams maybe follow the work mode, guessed by the expert.

4.1.4. Documents

Not as traditional waterfall method, zKVM developers do not create many documents. Only 3 kinds of documents are needed optionally:

- Line Item specification – this is the most important document created by each developer or his leader for describing the features of a Line Item, and reviewed by all team leaders including test team leaders, and then sent to test teams for designing their test cases;

- Legal Clearance – since the development work is around the open source projects, Big Iron, as a commercial company, has to make sure every line of codes are clear of legal issues.
- Design Document – optional. If the design of a Line Item or a component is very complicate, and might be dependent by other components, developers might be required to provide such a design document. As the specification, the design needs be reviewed and approved by all team leads and architects.

4.1.5. Communication

Efficient and effective communication is highly valued in Big Iron, of course, including the zKVM teams. A few helpful tools are utilized in the daily work:

- Lotus Notes – is an efficient document based database system, which has a great mail system support. Every team member is closely working with others with mail to exchange ideas.
- Lotus Sametime – is an enterprise class, modern Instance Messaging tool, allows everyone can text, voice or video call everyone in the world inside Big Iron instantly.
- Lotus Connections – is a full-featured social platform, allows all developers and testers to share the information with blogs and wikis.

4.2. Development Methods, tools and practices

zKVM project is based on 3 open source projects: Linux, QEMU and Libvirt. All 3 projects are written purely in C programming languages, but each with its specific coding styles.

4.2.1. Coding Editors

Editors' selection might be the only flexible choice of each developer, who can use whatever editors they like most. But basically Vi and Emacs are the 2 most popular among the developers. Even they are not friendly as GUI IDE like Eclipse or Netbeans, and have a steep learning curve to master, they are still the preferred editors. With rich plugins, these 2 editors could become as powerful as GUI IDEs, even with higher coding efficiency.

4.2.2. Development Environments

Since the project is for Mainframe machines, which have totally different architecture than x86, so a zVM virtual machine is set up for every developer, and a SSH connection is open to the developers for remote connection.

On the virtual machine, developers can build and test their codes at any time.

4.2.3. Code Repository

As up streams, all source codes are managed in a central git repository, which has a remote connection to upstream repositories. Every developer has a branch on the git repository server to share his or her works at any time. Code is the most important document for zKVM project, which is believed that only code talks the truth.

4.2.4. Code Review

Completing the code and make it work without any issue on the test machine is just a beginning, the most difficult task is to have your finished code being reviewed by every developer in the team, and afterward, reviewed by every Linux/QEMU/Libvirt developers around the world.

All the workable codes are sent to a team's public mailing list with an increasing version number, every developer's part of daily task is to review the new changes to the system. The review is as strictly as palaeontologists investigating the fossils with a magnifying glass. With such rigorous check, most of the possible defects are cleaned up before officially submitting the codes to master – the production branch.

4.2.5. Testing

Every developer is not responsible for testing work, which is covered by the separate testing teams, who are more experienced and skilled to conduct the tests. Roughly there are a few testing teams for different testing phases.

- FVT (Functional Verification Test) – for verifying the features according to the specification written by each developer. Corresponding developers review all the test cases.
- SVT (System Verification Test) – for verifying the zKVM product as a whole. The interactions of each feature are the focus of this phase.
- IT (Integration Test) – for verifying the integration abilities of zKVM with other products, like DB2, WAS, etc.
- Performance – for comparing the performance of zKVM with zVM and other hypervisors in market to make sure that zKVM remains competitive in the virtualization market.

4.2.6. Testing Tools

Besides the traditional Linux GNU tools for daily development and testing, the test team has developed an automation system called TP4 (Testing, Preparation, Performing, Parsing,

Presentation). TP4 could help both developers easily provision a test environment and execute the test cases, and then generate a visual report.

4.2.7. Builds and Smoke Test

With developers' daily submission of new codes, a build machine operated by a build team is helping generating a daily builds for all developers and testers. Testing teams have elaborately select a sub set of test cases for the build team to run for each of these builds, so that developers could get a quick report on his latest codes and see if it breaks anything.

The subset of test cases constitues the smoke test, they are maintained carefully by the test teams.

4.3. Success Factors

Of all the factors contributing the success of the project zKVM or alike, the following critical factors are highly valued:

- Teamworking – a project is driven by a group of diverse people, the cooperation of everyone determines the efficency, even the destiny of the project. Having a teamworking spirit in teams, especially in large scale project like zKVM is essencial for the final success.
- Commitement – one of the disadvantage of waterfall model is that the next phase is heavily depending on the previous phase to start their working, the deadline of one feature could impact the whole project's progress and plan. No matter what the problem is, the deadline must be met to make sure the project is going smoothly to next stage.
- Technical Skills – project like zKVM is half research project, a deep understanding of computer architecture is a must for each developer, a rich technical skill set is essentical to complete the tasks assigned.

5. Challenge and Recommendation

There are 2 issues or challenges in the zKVM and similar projects within Big Iron, which are both about employee churn.

- Steep Learning Curve - albeit zKVM developers have moved from Big Iron's proprietary programming languages to the open source platform Linux and public well-known C language, the exclusive mainframe hardware architecture is still an unavoidable barrier for new developers. For a new developer to get familiar with this

new architecture and start to be able to produce reliable codes, it needs at least 3 months training or even long up to 6 months.

- Competitors' Poaching - since Big Iron is not the only software provider in virtualization market, and a lot of the development techniques are common among the KVM world, a seasoned developer is very likely targeted by competitors, because they are publicly popular in the open source community.

Due to the above 2 challenges, zKVM team is under the pressure of facing the employee turnover and bearing the corresponding consequences.

Allen (2008) analysed the different types of turnover happening in all organizations, and he suggested that each organization should develop a retention strategy to avoid employee turnover and make plan for those avoidable turnover. The main factor of employees leaving right now is the poaching of competitors with higher salary offer, as Allen (2008) suggested, providing higher compensation and rewards seems the only countermeasure for Big Iron right now to prevent the experienced developers leaving.

6. Conclusion

Although the zKVM project in Big Iron is following the traditional waterfall development model per the expert, however, from the case study Agile practices are definitely seen in their daily development work, such as the extremely simplified documents, occasional meetings within team, and weekly meetings between team leads from 4 regions. zKVM project seems have found a perfect balance between the waterfall and agile practices to best suit their needs.

Clearly both Agile and Waterfall models have their advantages and disadvantages, both could fit in certain contexts. Adhering to a pure Agile or Waterfall model is not a pragmatic approach, unless it could provide the best support. As Sulleyman (2014) reported, "a healthy mix of agile and waterfall produces the best results". Without doubt, Big Iron is wisely choosing such a hybrid model for their zKVM project.

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8. Appendices

8.1. Questions prepared for expert

8.1.1.What important software development methods and practices do you think I should understand to be part of a successful development team?

To be part of a successful development team, one must understand fully the software development process, which includes planning, requirements analysis, design, coding, testing, and documentation 6 different phases. All methodologies follow these phases.

With the prospect of Agile development method, we(IBM) are trying to adapt it into our daily development projects. But still we are more working with the traditional waterfall development method. One of the important reasons is that it is not easy to adapt to Agile for a team with 40+ developers only, not including testers and other staff. We are developing a product aiming to release after a 2-years development period. All requirements are discussed and decided by product architects, who are analysing the market requirements and dispatch those requirements as separate features to each development teams. All developers and testers will only accept the features description and develop, test and deploy the codes.

Within each development and test team, we are distributing all the feature user stories into each iteration, which normally takes 4 weeks.

If you are asking me what method we are using? I would call it more a Waterfall than Agile. But we do have some agile practices, not strictly applied, like Daily standup - we have a standup meeting every 2 days or 3, depending on the development status. Every Thursday, we 4 team leads around the world gathered together have a team sync up meeting. It is more like status report, which takes half an hour to 45 minutes.

We are managing the features with user stories in the famous agile development platform: Rational Team Concert(RTC). All the user stories are assigned to every developer and tester. Each story has only 3 status : Not Started, In Progress or Completed. We don't measure the stories with story points, but only set a completion date for it.

So you see, we are still working in Traditional waterfall method, but we are trying to take advantage of the agile practices to improve our development efficiency.

Back to the question, every developer should understand the waterfall method, only after he understands that, he can adapt to the other methods, because all the other methods are all variations of it.

8.1.2.What roles do you think are needed in a successful software development team?

For a successful development team, a system architect is mostly needed. The bigger the product is, the more important a good architecture is needed. This is more true in an agile development team. Project manager is another important role as well, who manages the team development progress to make sure the product is delivered on time to market or client.

A product owner or requirement analyst is needed if we need deliver a project to client. They are the bridges between the customers and development teams.

Last but not least, developers and testers are the mainstay of the product or the project. The quality of the product is ensured by them.

8.1.3. I have been told that it is important to treat testing as important as coding through using methods like automated regression tests, automated builds, and a test first approach. What do you think?

Test is treated as equally as important in our company. The ration of developers to testers is like 1:2+. That is to say, we have 2 times more testers than developers for a project. Before delivery of a product, we have 4 phases of test to ensure the quality: Unit Test(developer), Function Test and Globalisation Test, System Test, Integration Test. For part of our products, we even have more test phases including performance and scalability test, service test.

But we can not test before development for all phases. For Unit Test phase, developers are developing their test cases in JUnit or CUnit code when they create their code. All the other phases are planned after development time

8.1.4. We learn about practices like stand-up meetings, sprint planning and sprint reviews to keep in touch with other team members and the client in some projects. What would you recommend to keep in touch and get feedback during development?

As mentioned above, we have 4 international teams working together for a product. We 4 team leaders keep meeting every Thursday to synch up with each team's status. For our local team, we have a regular meeting every 2/3 days. The meetings are bit longer than standard standup meeting like 30-60 minutes. We share with each other the past progress and the issues, and then we discuss a solution as a team.

we don't have sprint planning, which is done by German team. We don't have sprint review meeting

For keeping in touch with other team members, we are using the most traditional mailing list to ask questions and post our development patches, asking for comments on that. Everyone can check and comment on the patch codes.

8.1.5. We have been told that you review the team process in retrospective meetings after every sprint and it’s ok to experiment with the process and make changes. This is part of continuous learning for the team. What do you think works well to keep the team learning?

We don't have retrospective meetings for a sprint. But we do have similar meetings at the end of one milestone or a release. We will review what have been done well, and what are not.

8.1.6. There are lots of tools to help with software development methods, like continuous integration tools. What do you think the important tools are to support development team over the development lifecycle?

Tools are just tools, they are used by men, who can make the best out of them, or nothing. Different projects have different natures. Different people have different preferences. Like in our team for code development, projects are developed in C code, someone likes to use VI, others like Emacs, and others like Eclipse or Netbeans.

But for project management, we all use the same defect management system: Rational Quality Manager(RQM). One of the team is using Bugzilla, this caused some conflicts when we work across the 2 teams. But now they are trying to migrate to RQM.

For code repository, we are using git to manage all the codes from every team in a central git server. Our build team creates a daily build from the repository and executes a regression tests afterward. The test results is available for all developers.

For our local team, we have a Team Room database to record our development status and share all the development skills there.

As mentioned above, we are using RTC to manage all our stories, it has a rich set of features for Agile development, like the Dashboards, Story board and Task board, burndown/burnup charts.

8.1.7. What do you think the main success factors are, with respect to methods and tools in developing software?

To my understanding, the main success factors are the quality of the product and the delivery on time because we are developing a product targeting a market.

If we are working for a client to deliver a project, I would put customers' satisfaction in the first place, while keeping the above 2 factors.

8.1.8. In your opinion, what are the main challenges related to software development methods and tools I should learn about.

The main challenge is not there is a method and tool for you, but there are too many and you have to gradually find the best for your project and teams. All public methods and tools have been proved successful by someone in the world. But integrating them into your project and make them work for you is the biggest challenge.

8.2. Expert Opinion of Critical Success Factors

Either for a team or a team player, team-working spirit is the primary key factor for a successful team. No one is perfect and no one can put everything on his shoulder to accomplish the project.

Second, would be the commitment, which is highly valued in teamwork.

Third, would be the technical ability to take over the tasks assigned.

8.3. Answers to curiosity question

8.3.1.How requirements are elicited (discovered)

Our requirements are collected by a product board, which consists of a few experts familiar with the market, collects requirements from different channels to all our customers. For a project, if we are working directly for a client, the requirements are analysed by our team lead and team's requirement analyst. Then all the requirements are documented as UML diagrams and use cases. After confirmation with customers, all the requirements are dispatched to developers and testers.

8.3.2.How shared understanding of requirements (elaboration, clarification) is done

As said, we create documents on the requirements, and meet with customers to confirm.

8.3.3.What is done for release planning and scheduling

The management team decides the release plan and schedule. Out of scope of our developers.

8.3.4.How the order of features to work on (priority) is agreed on

Every feature is prioritised, with a High, Middle or Low ranking. We will first work on the High priority features for most of the time.

8.3.5.How the expected effort to develop features is estimated for planning

We first assign the features to a developer and a tester, then the team lead will work with the developer/tester together to estimate how long he(they) needs to develop.

8.3.6.How the progress of the development is monitored

Periodically team lead will review the development status with each developer, and check if there is any risk for delivering the feature at scheduled time.

8.3.7.How the team is organised – what roles and responsibilities

For our team, we are just a small dev team(7), among a far bigger team which consists of more than 100 staff. The roles include but not limit to: project manager, team leads, developer, tester, and architect.

8.3.8.How the team keeps in touch with each other

regular meetings, and using mailing list to review codes.

8.3.9.How the team keeps in touch with the client (product owner)

N/A

8.3.10. What the team's reaction is to changes in features

We seldom see requirement changes.

8.3.11. Do the team experiment with process and practices

No, our process and practices are fixed

8.3.12. Do the team reflecting and continuously learn

N/A

8.3.13. How iterative and incremental development is done (e.g. three week sprints)

We have a 4 weeks iteration definition. All features are put into those iterations.

8.3.14. How requirements are documented/represented (eg user stories)

are documented as User stories in RTC

8.3.15. How changes to requirements are handled

N/A

8.3.16. How testing is done and what levels of testing– unit, regression, integration, acceptance, performance, load.

see previous section.

8.3.17. What testing is automated

All testing is automated as much as possible.

8.3.18. Is exploratory testing done?

N/A

8.3.19. Is test coverage measured

Yes, Test Team will measure the coverage of all features in delivery, and determine if the coverage is good enough for the product

8.3.20. Are any quality metrics (measures) tracked?

We make sure there is no severity 1 defects left in released product

8.3.21. Is a test first approach used? How is the build managed– any automation?

see previous section, test first only applied in Unit Test phase

8.3.22. How about the frequency of the builds?

Daily builds, we also keep some gold builds

8.3.23. How is Continuous integration achieved?

Build team collects a minimum set of tests from test teams, and execute the tests right after builds, a test report is published along with the builds to developer

8.3.24. How are non-functional or quality requirements managed?

Out of my understanding scope.

8.3.25. What programming languages are used?

C for product, Bourn Shell, Python, Perl and other scripting languages for Test

8.3.26. Are there any other important tools?

n/a. All useful GNU tools might help