Lean Software Development
Taylorism, Fordism, and Lean Thinking
Lecture 7

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Taylorism

Taylorism (Scientific Management), is a theory of management that analyzes and synthesizes workflows. Its main objective is improving economic efficiency, especially labor productivity. It was one of the earliest attempts to apply science to the engineering of processes and to management

Main ideas:

- rigid and detailed upfront planning;
- division of labor and specialization of the workforce; and
- the clear formalization of a problem and division of a large problem in small sub problems

Frederick Taylor (1856-1915), leading proponent of scientific management

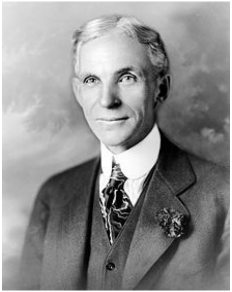
https://en.wikipedia.org/wiki/Scientific_management

Fordism

"the manufacturing system designed to spew out standardized, low-cost goods and afford its workers decent enough wages to buy them"

Major success stemmed from three major principles:

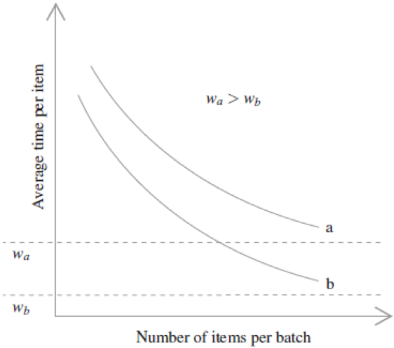
- The standardization of the product (nothing hand-made: everything is made through machines and molds by unskilled workers)
- The employment of assembly lines, which used special-purpose tools and/or equipment to allow unskilled workers to contribute to the finished product
- Workers are paid higher "living" wages, so they can afford to purchase the products they make



Henry Ford (1863-1947)

https://en.wikipedia.org/wiki/Fordism

Fordism: economies of scale



- p – the time to prepare the instrumentations and the tools
- a – the time for the acquisition of the raw material
- w – the time to do the actual work to produce the car
- d – the time for the disposal of the tools and the dismissal of the waste

Fordism: economies of scale

if we produce one item at a time, the total time to produce an item (alone),

$$t_a = p + a + w + d$$

and the time to produce n cars T_a is

$$T_a = n \times (p + a + w + d)$$

if we produce n cars in one batch, then, roughly speaking, the time to produce the batch T_b is

$$T_b = p + a + n \times w + d$$

The larger the number of cars n, the lower the production costs for one car.

The phenomenon of the reduction of average cost per item when the number of items increases is called “economies of scale” because scaling up the production results in better economies

The Origins of Lean Thinking

In the late 1940s, a small company named Toyota set out to manufacture cars for Japan, but it had a problem.

Since people did not have much money, cars had to be cheap. Mass production was the cheapest way to make cars, but mass production meant making thousands of the same kind of car, and the Japanese market was simply not large enough to need all those cars.

So the question was, how could Toyota make cars in small quantities but keep them as inexpensive as mass-produced cars?

Waste is anything that does not add value from the customer point of view

> All we are doing is looking at the timeline from the moment a customer gives us an order to the point when we collect the cash. And we are reducing that timeline by removing the nonvalue-added wastes.

Taiichi Ohno
1912-1990

http://www.slideshare.net/Cartmendum/intro-2-lean

Waste is anything that does not add value from the customer point of view

The seven Wastes of Manufacturing	The seven Wastes of Software Development
Inventory	Partially Done Work
Extra Processing	Extra Processes
Overproduction	Extra Features
Transportation	Task Switching
Waiting	Waiting
Motion	Motion
Defects	Defects

http://slideplayer.com/slide/5271317/

Waste: Partially Done Work

The big problem with partially done software is that you might have no idea whether or not it will eventually work.
Sure, you have a stack of requirements and design documents. You may even have a pile of code, which may even be unit tested.

But until the software is integrated into the rest of the environment, you don't really know what problems might be lurking, and until the software is actually in production, you don't really know if it will solve the business problem.

Addison Wesley - Lean Software Development - An Agile Toolkit

Waste: Extra Processes

- Any effort that does not add value to the product or service
- Re-work loops or work-around
- Redundant process steps
- Extra fields requiring unused information
- Multiple signatures
- Unnecessary completion of templates, forms, documents

http://www.slideshare.net/goleansixsigma/lean-six-sigma-the-8-wastes-goleansixsigmacom

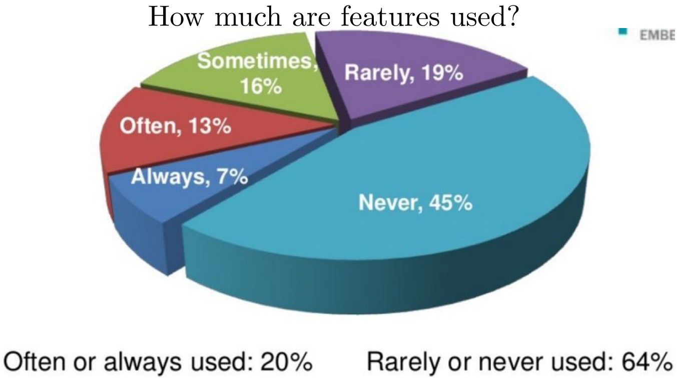
Waste: Extra Features

It may seem like a good idea to put some extra features into a system just in case they are needed. This may seem harmless, but on the contrary, it is serious waste. Every bit of code in the system has to be tracked, compiled, integrated, and tested every time the code is touched, and then it has to be maintained for the life of the system.

Every bit of code increases complexity and is a potential failure point. There is a great possibility that extra code will become obsolete before it's used; after all, there wasn't any real call for it in the first place. If code is not needed now, putting it into the system is a waste.

Addison Wesley - Lean Software Development - An Agile Toolkit

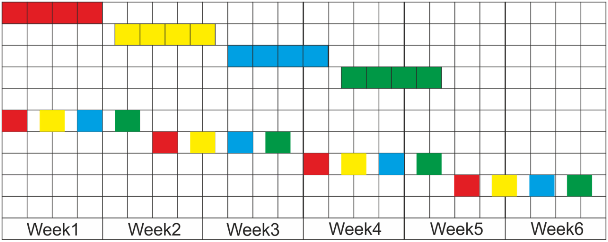
Waste: Extra Features



Standish Group Study Reported at XP2002 by Jim Johnson, Chairman
http://www.slideshare.net/AGILEMinds/mark-robinson-what-does-lean-mean-for-software-testing

Waste: Extra Task Switching

Assigning people to multiple projects is a source of waste. Every time software developers switch between tasks, a significant switching time is incurred as they get their thoughts gathered and get into the flow of the new task. Belonging to multiple teams usually causes more interruptions and thus more task switching. This task switching time is waste.

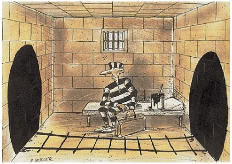


http://www.slideshare.net/Cartmendum/intro-2-lean

Waste: Waiting

One of the biggest wastes in software development is usually waiting for things to happen. Delays in starting a project, delays in staffing, delays due to excessive requirements documentation, delays in reviews and approvals, delays in testing, and delays in deployment are waste.

Delay keeps the customer from realizing value as quickly as possible. When a critical customer need arrives in your development organization, the speed with which you can respond is directly related to the systemic delays in your development cycle.



http://www.slideshare.net/Cartmendum/intro-2-lean

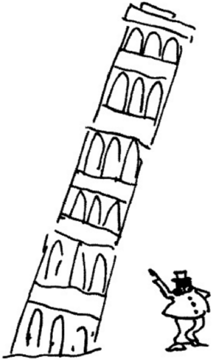
Waste: Motion

- Any movement of people which does not contribute to add value to the product or service
- Persons moving from one place to another create a false impression of being working, while in reality, are doing nothing. They are costing while adding no value.

http://www.slideshare.net/prosenjit08/waste-in-production

Waste: Defects

The amount of waste caused by a defect is the product of the defect impact and the time it goes undetected. A critical defect that is detected in three minutes is not a big source of waste. A minor defect that is not discovered for weeks is a much bigger waste. The way to reduce the impact of defects is to find them as soon as they occur. Thus, the way to reduce the waste due to defects is to test immediately, integrate often, and release to production as soon as possible.

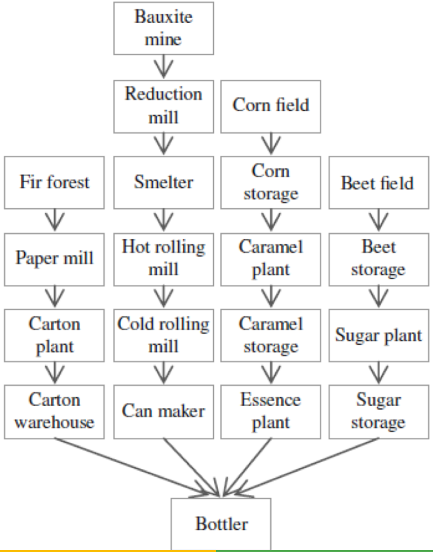


http://www.slideshare.net/Cartmendum/intro-2-lean

Value Stream

- A prerequisite for the identification of wasted resources is a clear understanding of the costs and benefits of the performed activities.
- The Toyota Production System advises to analyze the "value stream": all the required steps (value adding and non-value adding) to bring a product from raw materials to the customer are captured. The result of this analysis is used to identify methods to eliminate waste in the current production process.

Value Stream for Coke



The Value Stream for one box of Coke cans

Step	Incoming goods inventory (weeks)[a]	Time spent in Processing duration (min)	Finished goods inventory (weeks)	Spoilage in % of the initial amount of aluminium
Bauxite mine	0	20	2	0
Reduction mill	2	30	2	0
Smelter	12	120	2①	2
Hot rolling mill	2①	1	4①	4
Cold rolling mill	2①	1	4①	6
Can maker	2①	1	4①②	20
Bottler	0,6①②	1	5①②	24
Distributor	0①②	0	0,4①②	24
Store	0①②	0	0,3	24
Household	0,4	5	–	–
Total	5 months	3 h	6 months	24

[a] Including the time needed to transport the goods from the preceding step

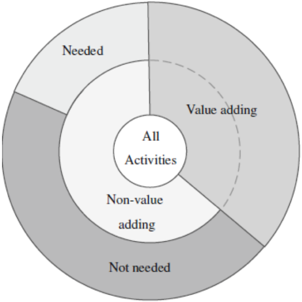
The Value Stream for one box of Coke cans

- the difference between effective productive work (3 h) and the total cycle time (11 months) is very high: 99% of the time nothing happens;
- the aluminum and the cans are carried through 12 storage facilities before they are offered to the customer (cells marked with 1);
- the cans are packed and unpacked three times on pallets (cells marked with 2);
- 4.24% of the extracted aluminum is lost because cans are damaged when packed empty at the can maker.

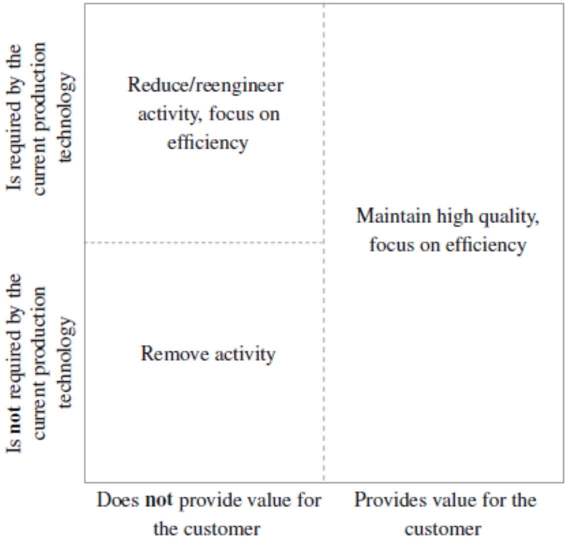
Classification of activities

The analysis of the value stream provides a picture of the value that the company provides to the end customer. This helps to classify activities into three groups:

- activities that add value
- activities that do not add value; these activities can be divided into:
  - activities that provide no value but are needed, e.g., because of current technologies, law requirements, or production methods;
  - activities that provide no value and are not needed, i.e., that can be removed.



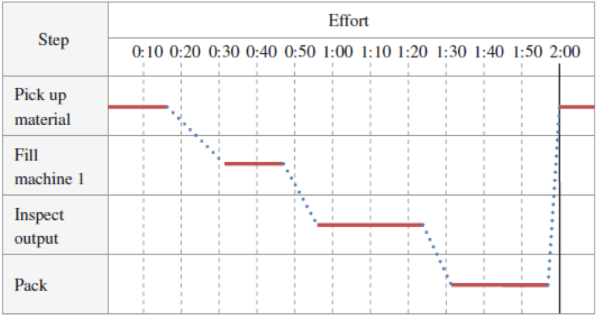
Classification of activities as decision matrix



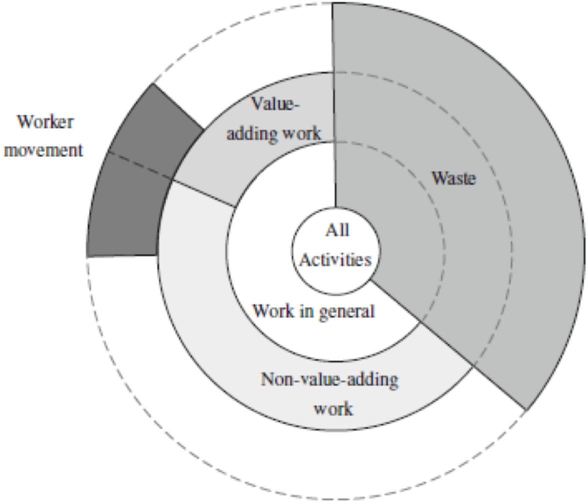
Standard effort sheet

Standard work sheets have a twofold function:

- They help to assess the current activities by workers. This creates awareness on how currently time and resources are spent
- They function as the instrument to standardize work, i.e., prevent workers from using different approaches (such as a different sequence) to perform their work.



Toyota Production System work classification



Pull and Push systems

In traditional manufacturing, the parts used during the production process are produced independently by every work station, temporarily stored in inventories, and used from there when needed.

Disadvantages:

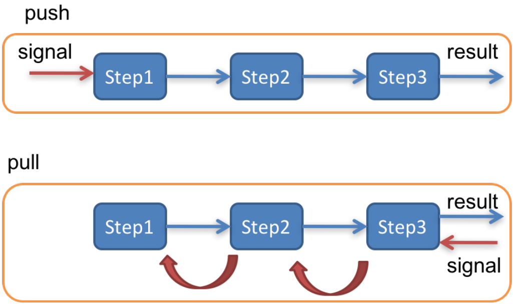
- opportunity costs: the costs of using resources like a storage room to keep goods that are not yet requested by customers instead of using these resources differently;
- risk costs: the costs that arise to avoid risks or to overcome the unfavorable event, e.g., an insurance against fire;
  conservation costs: the costs of conserving the goods in a good state, e.g., heating;

Pull and Push systems

- shrinkage costs: the costs of shrinkage of the goods present in stock because of reasons different from consumption like theft, administrative errors, or spoilage;
- management costs: the costs of managing the inventory and keeping track of the amount of shrinkage, what is stored, what is consumed, and so on;
- handling costs: the costs of moving products to, from, and within the inventory.

Pull and Push systems

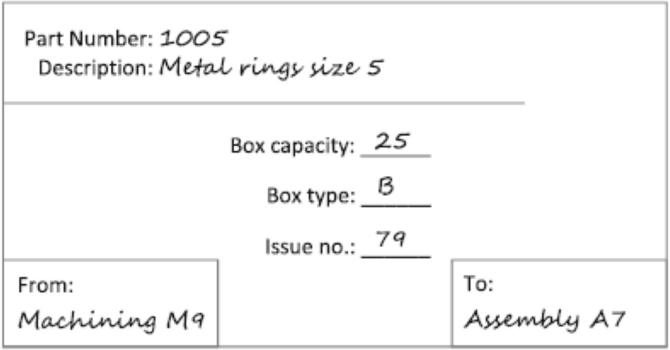
A decoupled production makes it difficult to understand if and how much value is provided by every single production step. The Toyota Production system changes this approach with the ambition to clearly define a "causality chain" where the contribution of each activity to the final output becomes clear.



https://en.wikipedia.org/wiki/File:CONWIP.png

Pull and Push systems

The way to trigger an upstream process chosen by the Toyota Production System is to send a message using a card (“Kanban” in Japanese). The example card in shows a retrieval Kanban that is used to retrieve 25 metal rings of size 5 from the production location “MachiningM9” and to deliver it to “Assembly A7.”



An example of a production process consisting of three steps (production, packaging, delivery). For every production step also who acts as a customer and who acts as a supplier are also specified.

Step	Activity	Customer	Supplier
1	A customer requires a product.	Customer	Delivery
2	The delivery process obtains the required item from the production process, packages it, and ships it to the customer.	Delivery	Production
3	The production process obtains the necessary raw materials from the suppliers, builds the requested item and ships it to the delivery process.	Production	Suppliers

Just-in-time production

To create a self-adjusting system to handle the production of parts "just in time," the Toyota Production System extends the Kanban system to "pull" parts and services from upstream processes (and in this way) to trigger their production.

Just-in-time production aims to perform activities only at the moment and in the amount that is currently needed, i.e., is providing value. Within just-in-time production, Kanban has the function to provide pick-up or transport information, to trigger production, to create visibility, and in this way to prevent overproduction and excessive transport (only items with a Kanban are produced or transported).

Just-in-time production

Traditionally, because of long setup times, the amount of same items produced has to be as high as possible so that the long setup time pays off (see Fig. 2.11, first line).

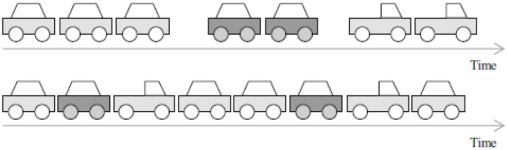
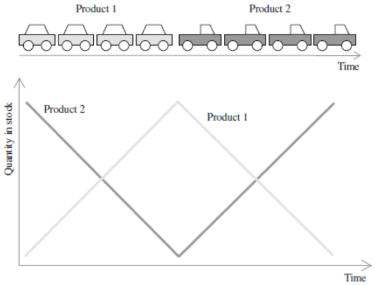
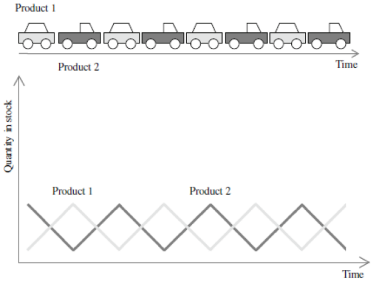


Fig. 2.11 Just-in-time production requires quick setup times

If it is possible to reduce the setup times, it is possible to produce items as they are required by the following processes (see Fig. 2.11, second line). This approach avoids overproduction: only those parts effectively used by subsequent processes can be produced.

Just-in-time production



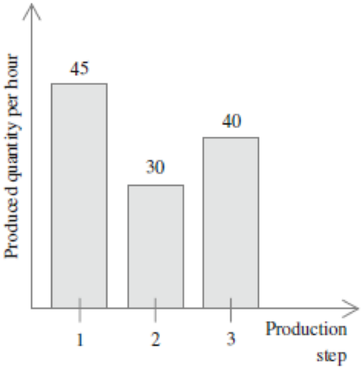


If items are produced as in fig above, items are produced on stock, which produces the costs mentioned above. This example assumes that products 1 and 2 are sold on a constant rate, but they are produced in this way to minimize costs.

If items are produced in small lot sizes, before switching to the next required item, the inventory size (and its costs) can be reduced. A prerequisite for this is a constant demand by the customers. If there are peaks in the demand, a buffer inventory is nevertheless needed

Just-in-time production

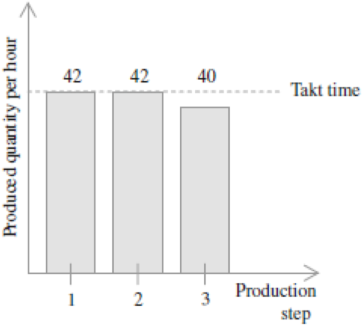
Figure shows an example in which the production of step 2 is the bottleneck (producing only 30 items per hour), while step 1 is producing 45 items per hour. This means that step 1 will produce items at a faster rate that they are used, which causes costs to handle this excessive production.



Unleveled production

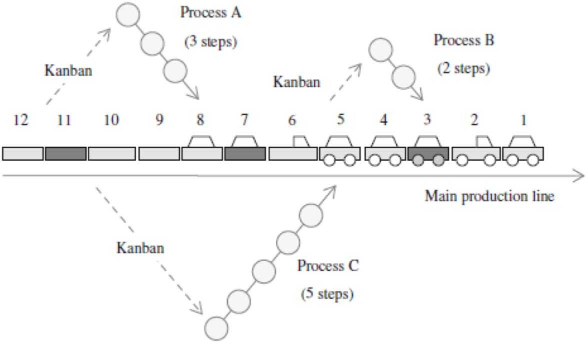
Just-in-time production

To align the production to the demand coming from the end customer, the speed of the just-in-time production is aligned to the speed of the demand. The production is aligned to "takt time," i.e., the total amount of products required divided by the total amount of hours available for production



Leveled production

Just-in-time production

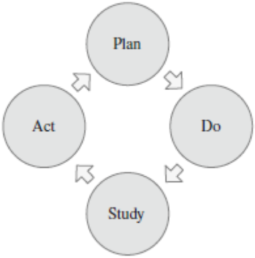


an automobile assembly line with three subprocesses (A,B and C).

Quality Management

Quality plays a central role within the Toyota Production System: the success on the marketplace is seen as a result of the quality of the products and services which are the determining factors for customer satisfaction. This assumption drives the constant search for improvement throughout the company.

The process consists of four steps: plan the activities to perform and their expected outcome; execute the plan (do); study the outcome and compare it with the expected outcome, i.e., understand how and why the realized result differs from the expected one; and confirm the plan or adjust it (act).



PDSA (Plan-Do-Study-Act) within the Toyota Production System

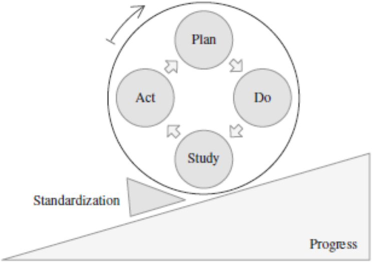
The PDSA process follows the methodology for conducting experiments used in science: hypothesis (plan), experiment (do), and evaluation (study).

Hypothesis	Signs of a problem	Responses
The person or machine can do the activity as specified in the standard worksheet	The activity is not done as specified	Determine the true skill level of the person or the true capability of the machine and train or modify as appropriate
If the activity is done as specified, the good or service will be defect free	The outcome is defective	Modify the activity
Customers' requests will be for goods and services in a specific mix and volume	Responses do not keep pace with requests	Determine the true mix and volume of demand and the true capability of the supplier; retrain, modify activities, or reassign customer-supplier pairs as appropriate

Quality Management

Standardization plays a crucial role in the Toyota Production System. It is the form how the company learns. Whenever a new aspect is learned, the standards (such as the standard work sheet) have to be updated to reflect the new method of production. Only through this the company can learn.

Figure shows a frequent way how this idea is depicted: the Plan-Do-Study-Act cycle helps the company achieve progress, but only standardization prevents the company from falling back to initial quality levels.



Summary

The “Leitmotiv,” the guiding theme for the Toyota Production System, is that an activity should be only carried out, if it provides value to the customer. The consequences of this are manifold:

- it is necessary to understand the contribution of each activity to the value for the customer;
- it is necessary to question current production methods to find new approaches that allow to eliminate all those activities that are not needed or only needed because of the current production method;

Summary

- it is necessary to involve workers in this assessment process because they are directly involved with the work and know the best of what is really needed and what is not;
- it is necessary to create a visible link between the creation of the value for the customer and all the carried out activities within the company: this is achieved implementing a "pull" mechanism;
- the goal is to make only "what is needed, when it is needed, and in the quantity that is needed" just-in-time production to minimize overproduction;