How the Web Brought Evolution Back into Design

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Adapted from slides by Paul Ammann & Jeff Offutt

Some engineering historical perspective

Building new technology incurs several **costs**

In today's lesson, I will separate costs into **four areas**

1. **Design**
2. **Production**
3. **Distribution**
4. **Support**

Over time, the relative amount of these costs have **continuously changed**

We started with the ability to **evolve our designs** slowly

Pre-1850: Hand-crafting

Design evolved over time, each new object better than the last

- Low **design** costs

Very high production costs – weeks of labor

Low **distribution** cost – customers walked into the shop

Little or no **support** cost

1850s: Assembly line

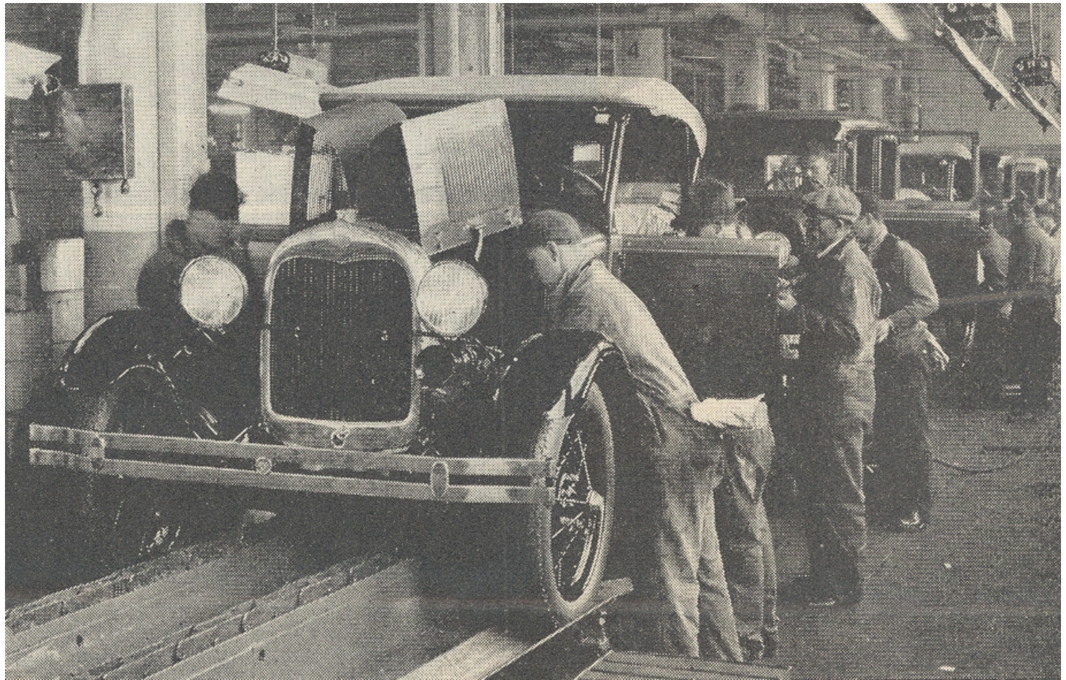
Manufacturing started to change this equation

Quickly put same design into **thousands** of products

Higher design costs ; **very low production** costs

Distribution costs started to increase

Support costs increased – but were outsourced



1900s: Automated manufacturing

Robots increased speed and efficiency of production

Design costs = create expensive robots

Production cost continued to *decrease*

Distribution costs continued to *increase*

Support costs also continued to *increase*

Post WWII worldwide distribution

Design costs continued to *increase*

Production costs continued to *decrease*

Distribution capabilities increased exponentially, decreasing cost

Support started to become "**replace**"

2000s: Free trade

This process had continued…

- free trade agreements
- cheap oil
- decreases in shipping costs
- decreases in production costs

The **ultimate effect**?

Design is VERY expensive

Production, distribution, & support are cheap

Manufacturing defeated evolutionary design!

Now we emphasize *quantity* over *quality*

Despite all these "gains"…

Thousands of products are incredibly **cheap**

Many products are very **low quality**

Designed to **last a few months** or years, instead of decades

Instead of **evolution**, we have

- **maintenance**, or
- **replacement**

But we lost something wonderful…

Craftsmanship

Sooo…

What does this have to do with software engineering???

Traditional software development

Production costs for software is *very low*

Distribution cost is *substantial*

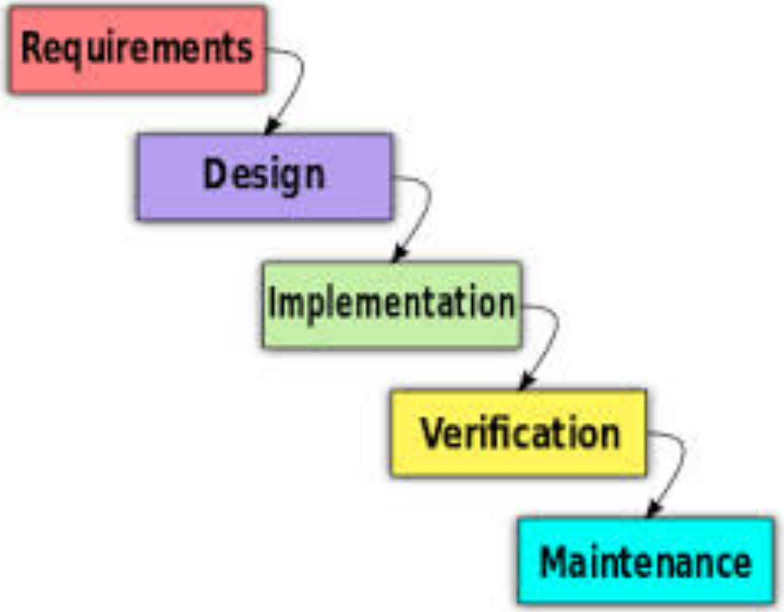
- includes marketing, sales, shipping

Support costs escalated

Software splits design into **design** and **implementation**

- both are very expensive!

Instead of one design for each artifact, software has one design for **many** artifacts



1900s software costs

Millions of **customers** skewed costs to the back end

- High support costs
- High distribution costs

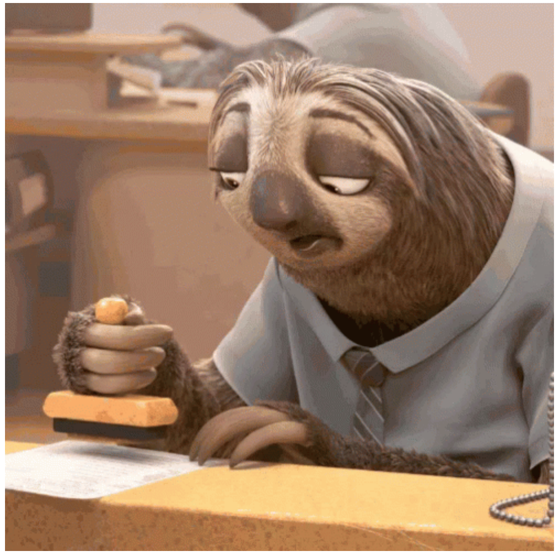
New versions **shipped** every 4-6 years

- MS Office, CAD, compilers, operating systems

Software needed to be "**perfect out the box**"

- Very **expensive design**
- Very **expensive implementation** – including testing more than 50% of the cost

Software evolution was very slow!



Effects on research

The need to be "**perfect out of the box**" heavily influenced *decades* of SE research

- formal methods
- modeling the entire system at once
- process
- testing finished products
- maintenance in terms of years

Much of our **research focus** and results assume:

- High **design** costs
- High **implementation** costs
- High **distribution** costs
- High **support** costs

Distribution costs

In the 1980s, technology started **driving down** distribution costs for software…

SCOPUS
100MB
Model 9883-91 Disk Pack
1983 Control Data Corporation (CDC)
X1715.99 L
Donated by Monterey Software Group Inc., Mountain View, California
SCOPUS

Usability and support

As **usability** started to increase…

The need for **support** decreased

Then the World Wide Web changed everything

2000s: The Web

(1) The web rearranged the importance of quality criteria, including making **usability** and **reliability** crucial

(2) The web created a new way to **deploy** and **distribute** software

Web deployment

Traditional software deployment methods

1. Bundle
2. Shrink-wrap
3. Embed
4. Contract

5. **Web deployment**

Distributing web software

Desktop software can be distributed across the web

- **zero-cost** distribution
- **instantaneous** distribution
- This allows more **frequent updates**

Web applications are not distributed at all in any meaningful sense

- software resides on the **servers**
- **Updates** can be made weekly…daily…hourly…continuously!

Mobile applications allow the artisan to come into your "home" to improve that rocking chair

The rebirth of evolutionary design

Near-zero **production** costs…

Immediate **distribution**…

Near-zero **support** costs…

This resuscitates evolutionary design!

Evolutionary software design

Pre-web software design & production

- Strived for a **perfect design**, **expensive development**
- **Deployed** a new version every 4-6 years
- **Evolution** was very slow

Post-web software production

- Initial "**pretty good**" design and development
- **Slowly** make it bigger and better
- Faster **evolution**
- **Immediate changes to web applications**
  - **Automatic updates** of desktop applications
  - **Software upgrades pushed out** to mobile devices *hourly*
  - **Replacing chips** in cars during oil changes

This changes *all* of software engineering!

Impact on industry

How often is **Google mail** updated?

- Daily … sometimes hourly

Piazza class support system

- Jeff report a bug the first day he used it
- It was fixed before he met for class *that afternoon*

Sarah Allen invented YouTube

- She advises people with 5-year ideas to think about how they can achieve 1 idea in 6 months, and *grow* to the 5-year goal

Current software engineering

Software will not be designed and built
Software grows

Software needs to take responsibility for its own **behavior**

Waterfall is now, finally, thankfully, completely dead

Testing must focus on evolution, not new software

The web really does change EVERYTHING!

Software process

We have already seen **process changes** that are a direct result of web deployment & distribution

Agile process goals:

- Have a **working, preliminary version** as fast as possible
- Continue **growing** the software to have more functionality and better behavior
- Easy and fast to **modify**
- Adapt to sudden and **frequent changes** in planned behavior

Agile processes are **widely used**

Results are mixed, but **use is growing** quickly

I DON'T ALWAYS SUCCEED IN MY SOFTWARE PROJECTS
BUT WHEN I DO, THEY'RE AGILE

Software architecture

Software architects often assume their high level design will **not change** throughout development

- and system lifetime

It is not clear how this supports **software growth**, **rapid deployment**, and **instantaneous distribution**

Is this attitude **compatible** with agile processes?

How does architecture design interact with **refactoring**?

Your generation needs to deal with this!

Software self-responsibility

Evolutionary design means we **cannot know** everything software will ever do

Self-management means the software adapts behavior to runtime changes – crucial for evolutionary design

Fault localization tries to debug automatically, which can dramatically cut the human effort required to fix software after testing

Automated defect repair goes one step further, and attempts to automatically fix faults

Software testing

Test-driven design uses tests to drive requirements

- every step is evolutionary

We must stop thinking of **regression testing** as something special done “late in the process”

- virtually all testing is now regression testing

Model-based testing allows test design to quickly and easily adapt to changes

Test automation is the key to running tests as quickly as software is now changed

TDD is an important part of this class

Software costs (then & now)

Old	New
Design: High	Design: **Medium**
Implementation: High	Implementation: **Medium**
Production: Low	Production: **Zero**
Distribution: High	Distribution: **Zero**
Support: High	Support: **Low**

Long term impact of evolutionary design

The end result of large scale manufacturing was a heavy emphasis on **quantity over quality**

The **web enables evolutionary design**, which can allow us to focus on quality over quantity

What engineer wouldn't LOVE that?!