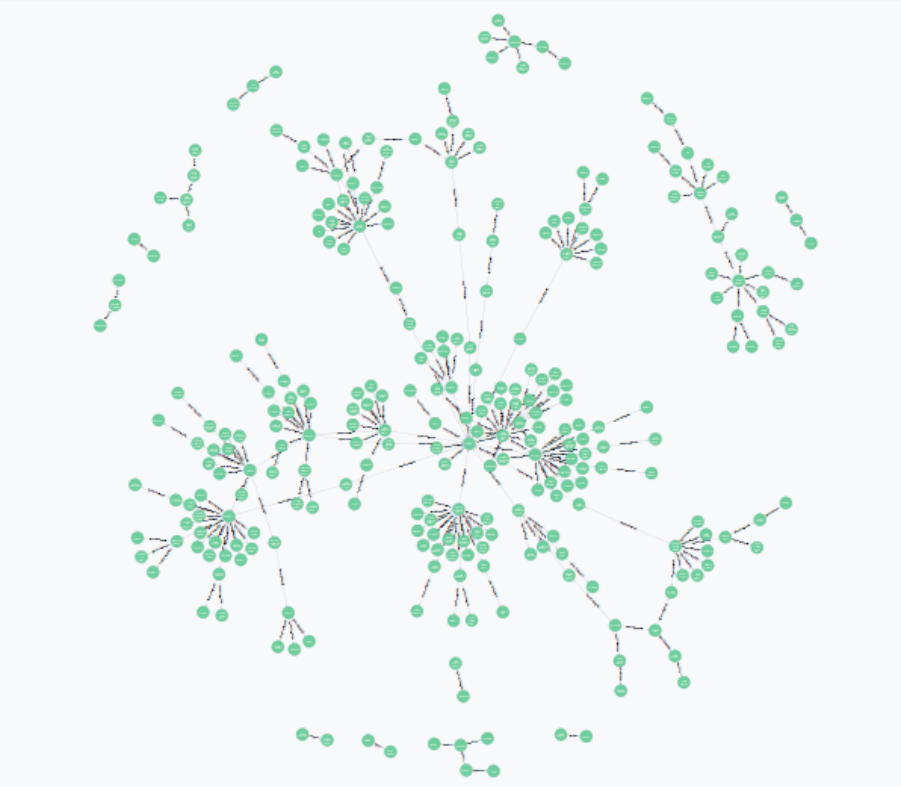
Live Software For RepRap Assembly Workshops



Torbjørn Ludvigsen

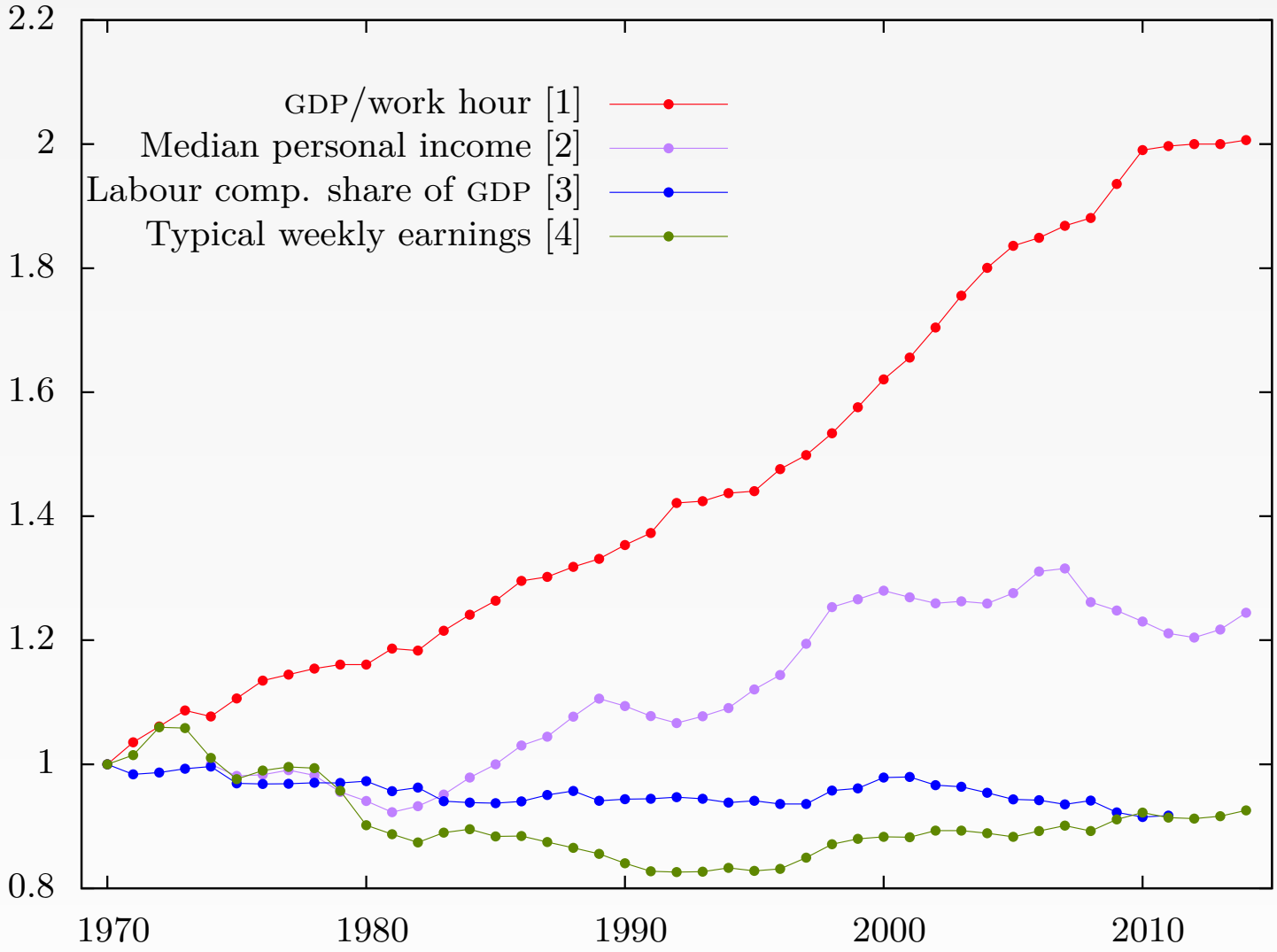
Introduction

Productivity
Simple machines: RepRap
Copyability
Structural Virality
RepRap Assembly Workshops
An Achilles Heel: Software

The Experiment

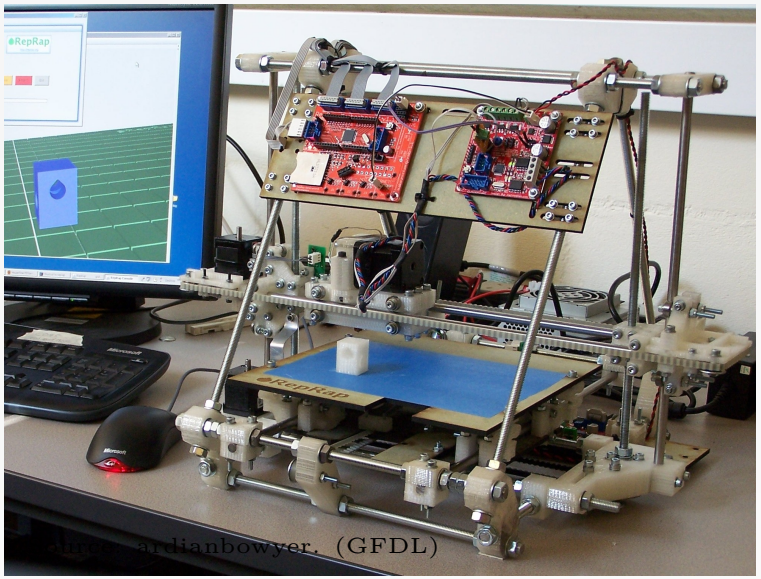
A Solution: Package Software With Live Operating Systems
Experiment Design
Boot Failure
Copyability Success Among Participants
Copyability Success Among Hosts
Yes, Live oSes Can Work
Fix The Boot Failure

Computer productivity payoff has not reached median income Americans yet.



They need simple, small scale machines.

T-Ford (1908)
Standard interchangable parts
Central production line

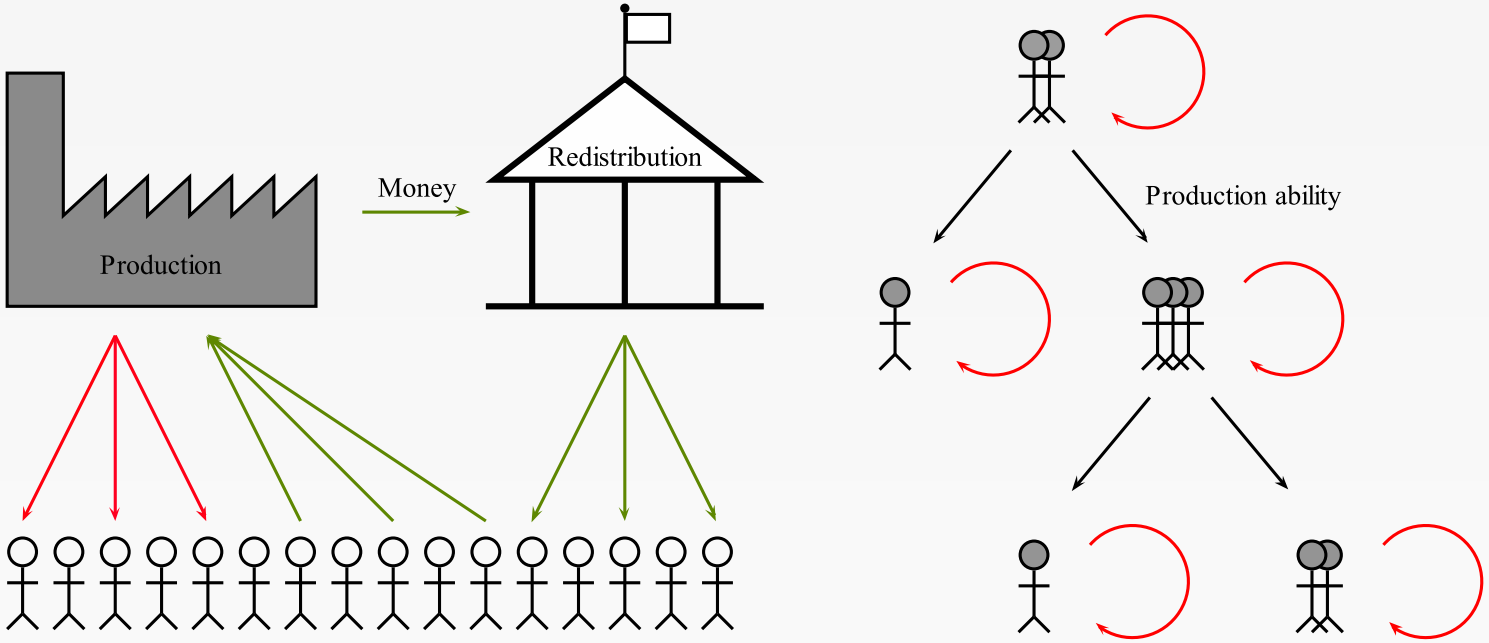


RepRap Mendel (2009)
Standard/self-manufactured parts
User production and distribution

Opportunity: RepRap 3D printers are numerous.

Problem: How to optimize user production and distribution?

User distribution requires optimizing copyability; the ease at which users can become independent suppliers.



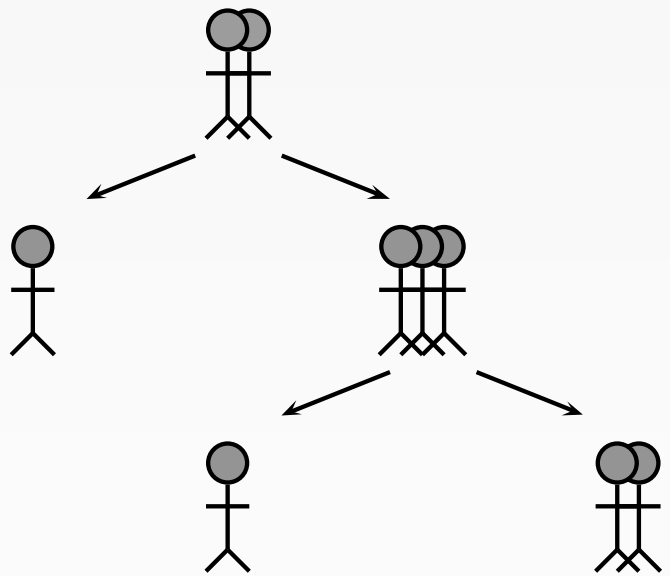
Extend T-Ford's success factors.

Price Unique Part Count Documentation	+	Software freedom Self-manufacture

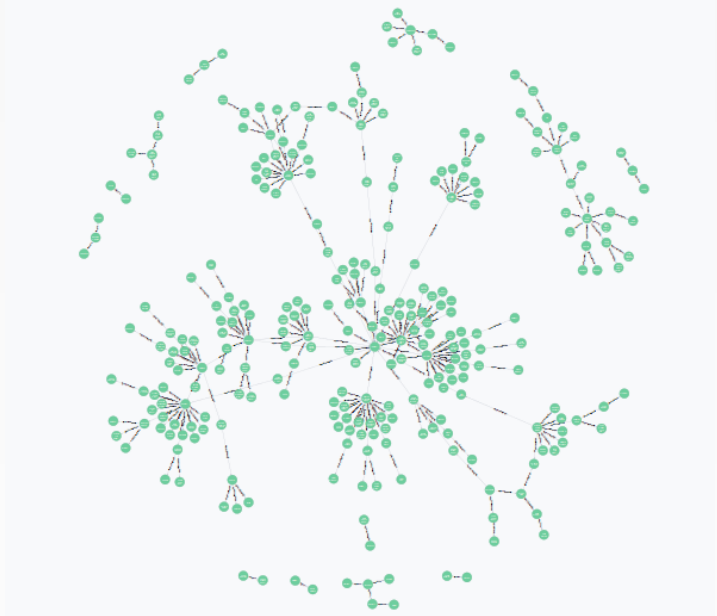
Measuring degree of user distribution means measuring structural virality over time.

$$\nu(T) = \frac{1}{n(n-1)} \sum_{i=1}^{n} \sum_{j=1}^{n} d_{ij},$$

T a tree structure, n number of nodes, d_{ij} length of shortest path between nodes i and j.

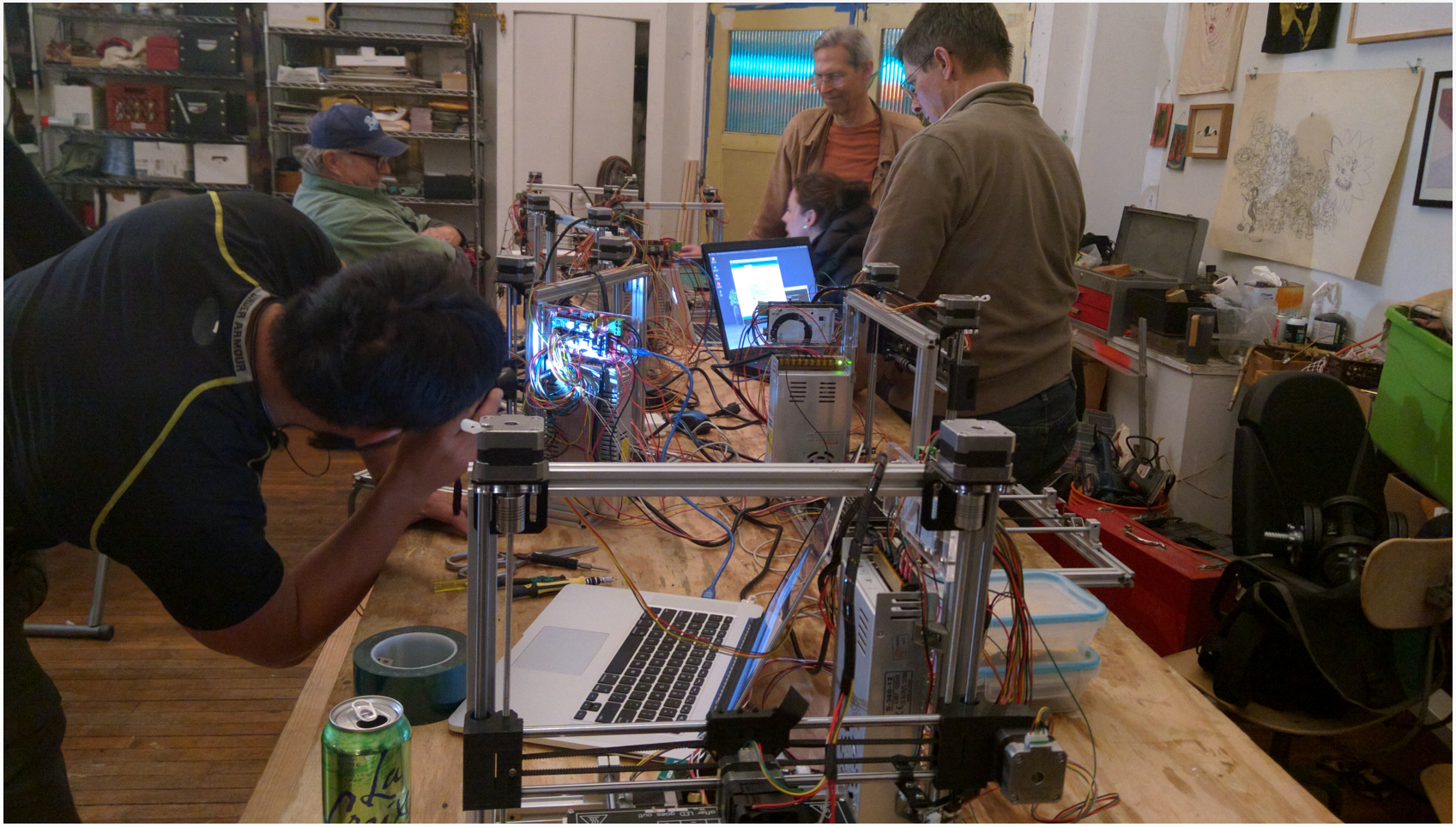


$\nu = 1.8$



$\nu = 5.0$ (3 years)

The most popular RepRap design has spread through RepRap assembly workshops; events where participants assemble their own RepRaps with supervision.



Software is an Achilles heel for the RepRap Community.

- Most common software toolchain: 5 different programs with different interfaces.
- Most RepRap community members more interested in contributing hardware than software.[5]
- Study shows 12 % of RepRaps in high schools “inoperable due to software issue”.[6]

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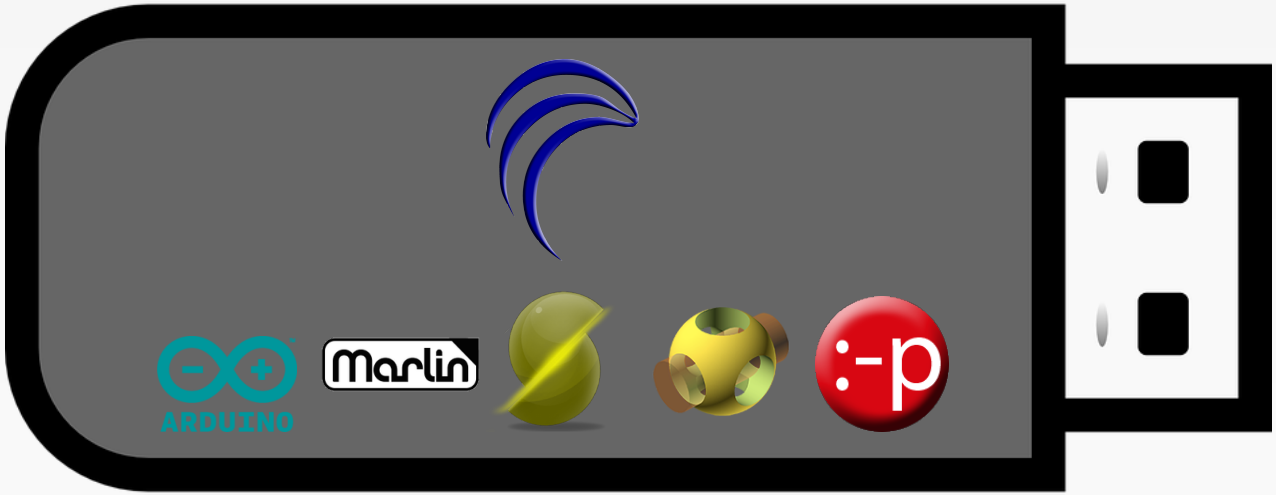
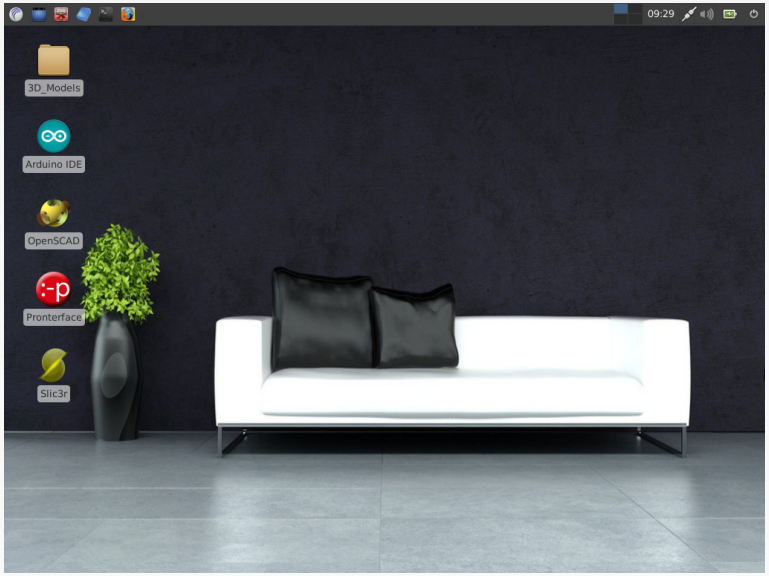
The software needed to host RepRap assembly workshops can be packaged in a live operating system.



- Users boot directly from portable media into configured system
- The problem of downloading, configuring and installing is reduced to the problem of distributing and booting the live OS.

We configured a live OS and tested it in a full experiment.

It booted into this screen. When participants pressed Enter the system was loaded to RAM and Pronterface (:-p) was started.



Participants who exited Pronterface, were presented with this desktop. Marlin was accesed through Arduino IDE (∞).

"Can RepRap assembly workshops aimed at the general public be shortened without decreasing their copyabiliy by swapping the steps of downloading, installing and configuring software with booting a live OS with pre-packaged software?"

Out of 11 participant groups, 5 failed to boot the live OS.

- 2 had Macbook laptops
- We don't know exactly for the last 3
- Time shortage and lacking preparations hindered optimal software supervision

Q: How would you rate your instructors? Did you feel you got sufficient support? What was missing?

"Definitely spread thin on instructor ratio regarding software, computer setup"

Participants regarded software as likely to hinder their 3D printing, but not their workshop hosting.

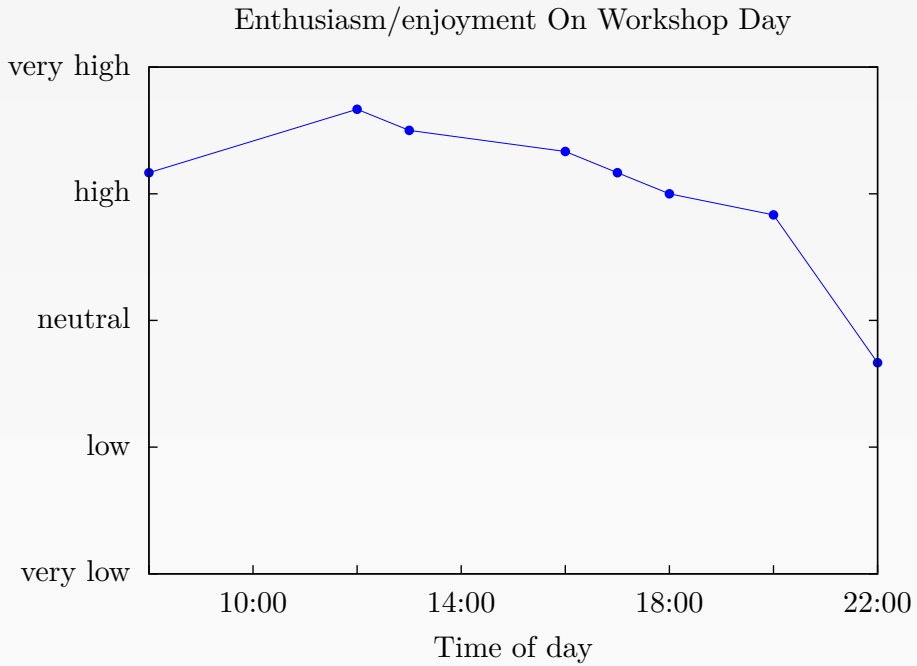
- 6 participants responded to a survey after the workshop
- 4 of them regarded software as the single link in their 3D printing toolchain that was most likely to break in ways that they would be unable to debug or repair.
- 3 said they were going host similar workshops themselves.
- No one mentioned software as a special challenge or hindrance to hosting workshops.

Hosts used the live OS to load the live OS onto participant USB drives and liked it as a workshop tool.

> *"Thank you for developing the USB stick - it worked like a charm [...]"*
>
> *– Catarina (instructor)*

> *"[...] the download and install process of all the software would clearly take significantly more time [...] we were simply unprepared in terms of helping people find the boot menu."*
>
> *– Marcin (instructor)*

The live OS *can* shorten RepRap assembly workshops without decreasing copyability, if used with care.



- Participants get tired towards the end of long workshops.
- Hosts should start with introducing the software. The live OS can serve manuals, video instructions and support lines.

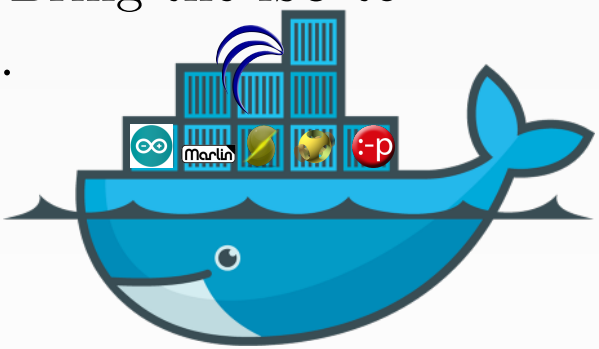
All participants must boot successfully.

Better instructions

- Detailed boot instructions per laptop model are required.
- Older Macbook models are most urgent.

More boot options

- Load the live OS on DVDs and CDs as well as USB drives.
- Keep a CD with a 32-bit version for very old laptops.
- Keep an install script for the rEFInd bootloader on the live media. It can make Macbooks boot live USBs if needed.
- The live OS ISO runs fine in VirtualBox. Bring the ISO to workshops in case virtual boot is needed.
- Create a Docker image from the live OS.



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OECD. *GDP per capita and productivity levels*. URL: http://dx.doi.org/10.1787/data-00686-en (visited on 05/02/2016).

US. Bureau of the Census. *Real Median Personal Income in the United States [MEPAINUSA672N]*. URL: https://research.stlouisfed.org/fred2/series/MEPAINUSA672N (visited on 05/02/2016).

University of Groningen and Davis University of California. *Share of Labour Compensation in GDP at Current National Prices for United States [LABSHPUSA156NRUG]*. URL: https://research.stlouisfed.org/fred2/series/LABSHPUSA156NRUG (visited on 05/02/2016).

Council Of Economic Advisers. "Economic Report of the President". In: *Washington, DC: US GPO, Annual. US Council Of Economic AdvisersEconomic report of the President* (2015). Table B-15: Hours and earnings in private nonagricultural industries.

Erik de Bruijn. "On the viability of the open source development model for the design of physical objects. Lessons learned from the RepRap project". In: *Unpublished Diss.(MSc Thesis). Tilburg University* (2010).

John L Irwin. "Evaluation of RepRap 3D Printer Workshops in K-12 STEM". In: *age* 26 (2015), p. 1.

Links

- d3d-Porteus Repo
- ose Wiki Category d3d
- QCface on ose Wiki
- d3d-Marlin Repo
- d3d_Workshop_Configuration Module Repo
- Clone Analysis Scripts Repo
- Computer Models Verified to Boot