

Commons-based innovation

The Linux kernel case

Motivation

The ICT sector is the sector contributing most to the development of the EU knowledge economy. One third of the business R&D expenditure gap is due to the smaller size of the EU ICT sector, while two thirds are due to the lower R&D intensity of the EU ICT sector as a whole. Factors contributing to the lower R&D intensity include sectoral composition and overall size of companies.

The Linux operating system kernel is a very successful example of a large software system in widespread use that has been developed using an open source development model. The Linux operating system is the most popular Free/Libre Open Source Software (FLOSS) in computing today. It has represented a \$21 billion ecosystem in 2007, expected to more than double in revenue by the end of 2012. As FLOSS, Linux is developed collaboratively, meaning no one company is solely responsible for its development or ongoing support. Companies share research and development costs with their partners and competitors, since 2005 over 5000 individual developers from nearly 500 different companies have contributed to the kernel. This spreading of development burden amongst individuals and companies has resulted in a large and efficient ecosystem and unheralded software innovation, freely available to society.

Methodology

Parametric cost model "Intermediate COCOMO81" is used to get better accuracy on our estimation of effort, considering the Linux Kernel to be a "semidetached" application.

$$Effort = a(Size)^p \prod C_i$$

Where a represents the impact parameters, $Size$ is the measure of output, p is exponent relating size to effort and fifteen C_i are the cost drivers. The parameters a and p are estimated from historical data. According to the model and previous literature parameters are estimated as $a=3$, $b=1.12$ and $TC=1.55$. Size of the project is measured using *Physical Software Lines of Code (SLOC)* as output. *Effort* results in person-months.

To calculate the cost for the Linux kernel, a base salary was estimated from the EUROSTAT. According to EUROSTAT, the average annual salary for a developer in 2006 was 31,040€. Most FLOSS development is global, so using a EU-average salary number is somewhat specious.

An overhead factor value is necessary to estimate the costs of office space, equipment, overhead staff, and so on. We use 2.4 as an estimate, which is used on literature applying COCOMO models to estimate FLOSS value.

The COCOMO model provides a rough estimation of the effort needed to generate software of a given size. Since this estimation technique is designed for classical software generation processes, the results it gives when applied to Linux Kernel should be viewed with caution.

Data base

- Kernel development history from version 2.6.11 to 2.6.30 (released from 02.03.2005 to 09.06.2009). Available from: Linux Foundation.
- Main variables: SLOC (total, added, modified and removed) days of development, commits, number of developers and employers.
- EUROSTAT: Mean annual earnings in high-tech manufacturing and knowledge-intensive high-technology services for upper secondary and tertiary education.

Results

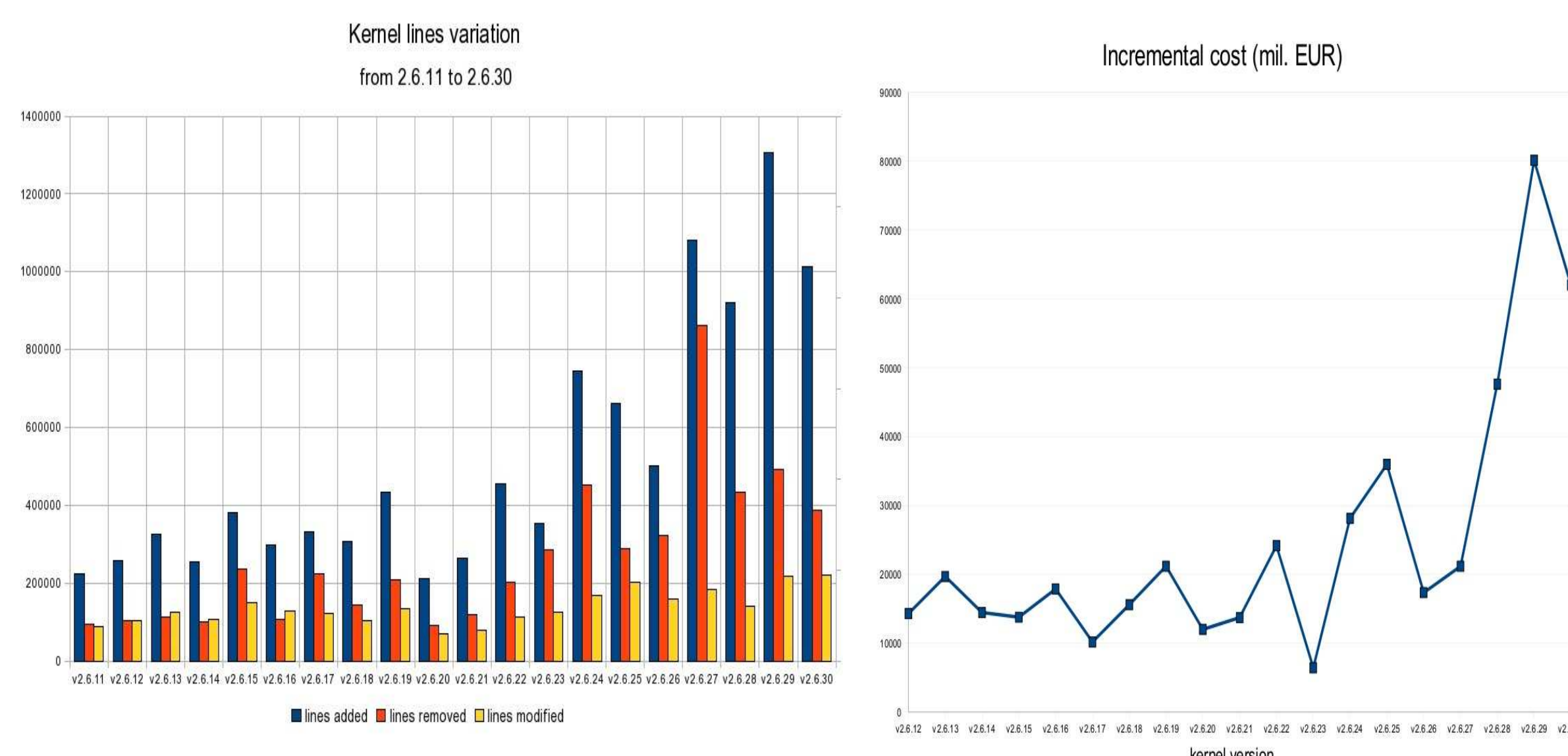
An estimated development value is calculated for each version. Differential costs are considered as R&D value. Results are validated against linear regression of developers observed on developers according to model ($R^2=86,49\%$).

For latest version (2.6.30):

- Estimated total value = **EUR 1,025,553,430**
- Estimated needed developers = 985.74
- Estimated time of development = 167.59 months (14 years)

Estimated annual R&D:

- 2005 (2.6.11 to 2.6.16): **EUR 80,141,810**
- 2006 (2.6.16 to 2.6.21): **EUR 72,704,900**
- 2007 (2.6.21 to 2.6.25): **EUR 94,729,880**
- 2008 (2.6.25 to 2.6.30): **EUR 228,353,700**



These results are also consistent with growth of R&D expenses on the ICT sector. Estimated 2008 results are comparable to 4% and 12% of Microsoft's and Google's R&D expenses on whole company products.

Policy implications

There is a great value on commons-based innovation. Because Linux kernel has been developed collectively, there is no single source for cost estimates of how much it has taken to develop the technology. Despite absence of book value, we think commons-based innovation must receive a higher level of official recognition that would set it as an alternative to decision-makers.

It's a business opportunity to EU's ICT sector, so partnership between large ICT firms, FLOSS SMEs and communities must be encouraged.

Legal and regulatory framework must allow companies participating on commons-based R&D to generate **intangible assets** for their contribution to successful projects. Otherwise, expenses must have an equitable tax treatment as a donation to social welfare.

Next steps

Costing models undercount the complexity inherent to FLOSS, because in a collaborative development model code is continuously added, but also deleted and modified. We also need to re-think models in order to include reuse, evolution and interfertilization of code by first creators and follow-on innovators.

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