A Trading Market to Incentivize Secure Software

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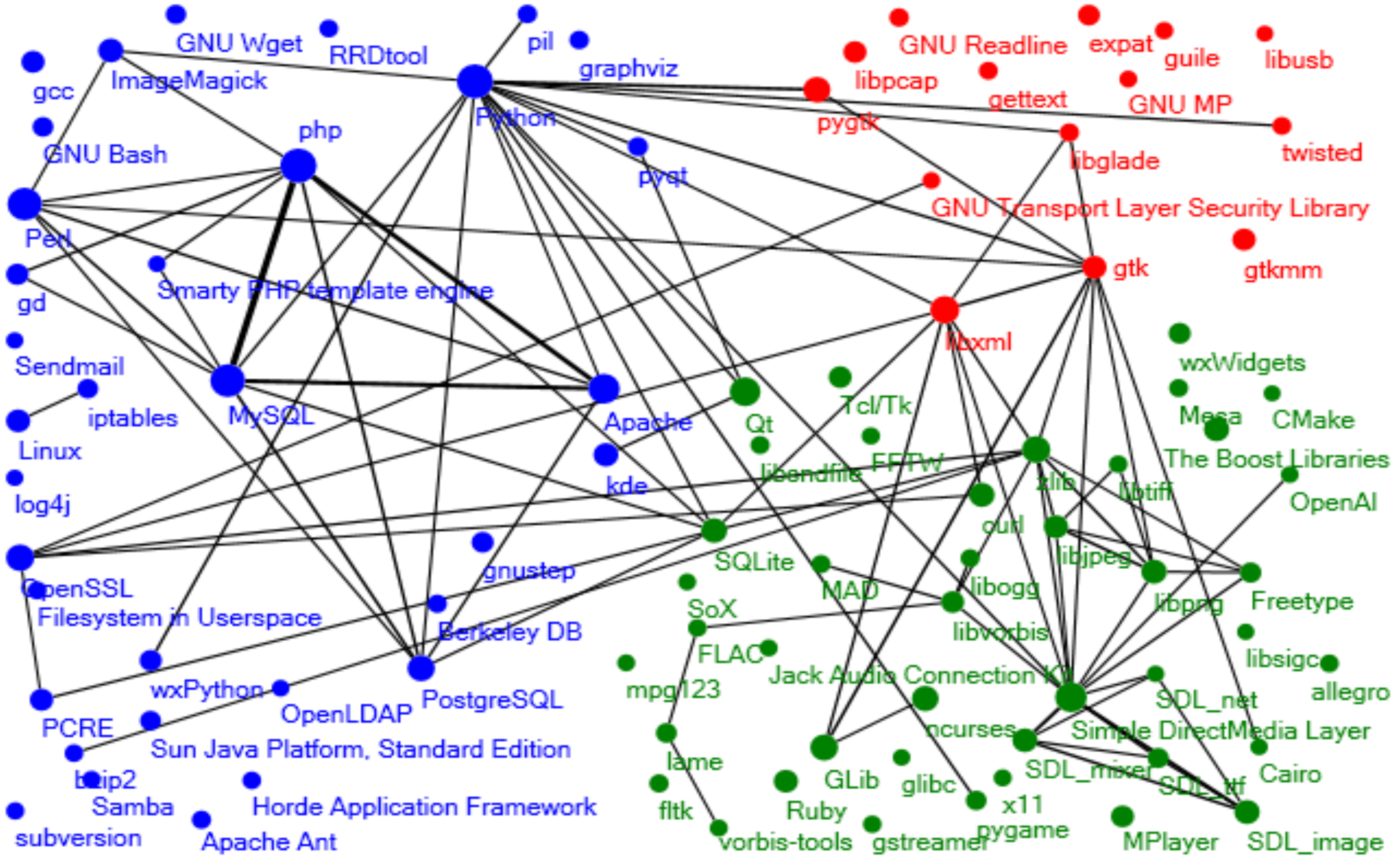
Outline

- Introduction
- Background and motivation
- Our approach
- Simulation
- Ongoing and future work
- Conclusion

Software today



Software today

- Software systems have evolved from an "input tape to output tape" model *to one of continuous interaction with other large systems*.

- Today's software systems exhibit behavior that is decentralized, interdependent, and dynamic.

Peer Production

(Coase's Penguin, or, Linux and The Nature of the Firm, Benkler 2002)

- A form of production where individuals self-organize to collaborate, self-match to tasks best suited to them.
- Characterized by decentralized conception and execution, diverse motivations, where projects are governed as common property regimes.
- Example: FOSS

Peer Production

- What could be better?
  - Funding digital infrastructure

    (Roads and bridges: the unseen labor behind our digital infrastructure, Nadia Eghbal 2016)

  - Price signals to align supply and demand

    (Kooths et al. 2003)

Research question

How can a market design incorporate price signals into peer production, facilitate information sharing, and promote quality?

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Our approach

- A trading market for software issues. Prototype is called *Bugmark*.
- Participants can *trade* futures contracts to elicit information on issues and to incentivize work.
- Users, developers, testers, project maintainers, investors, and others can trade on questions such as: *will a bug be fixed? will a vulnerability be found?*

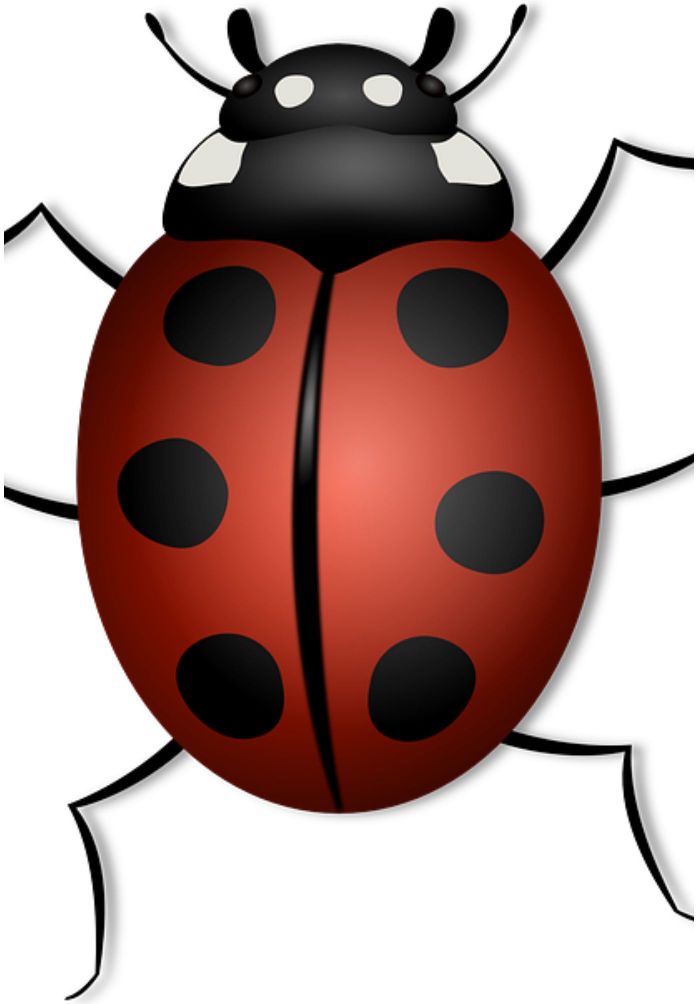
Our approach

- *How does it work?*

- User Adam finds a bug

- Adam is not a developer but has heard of Bugmark where he can pay to get the bug fixed

Courtesy Georg Link



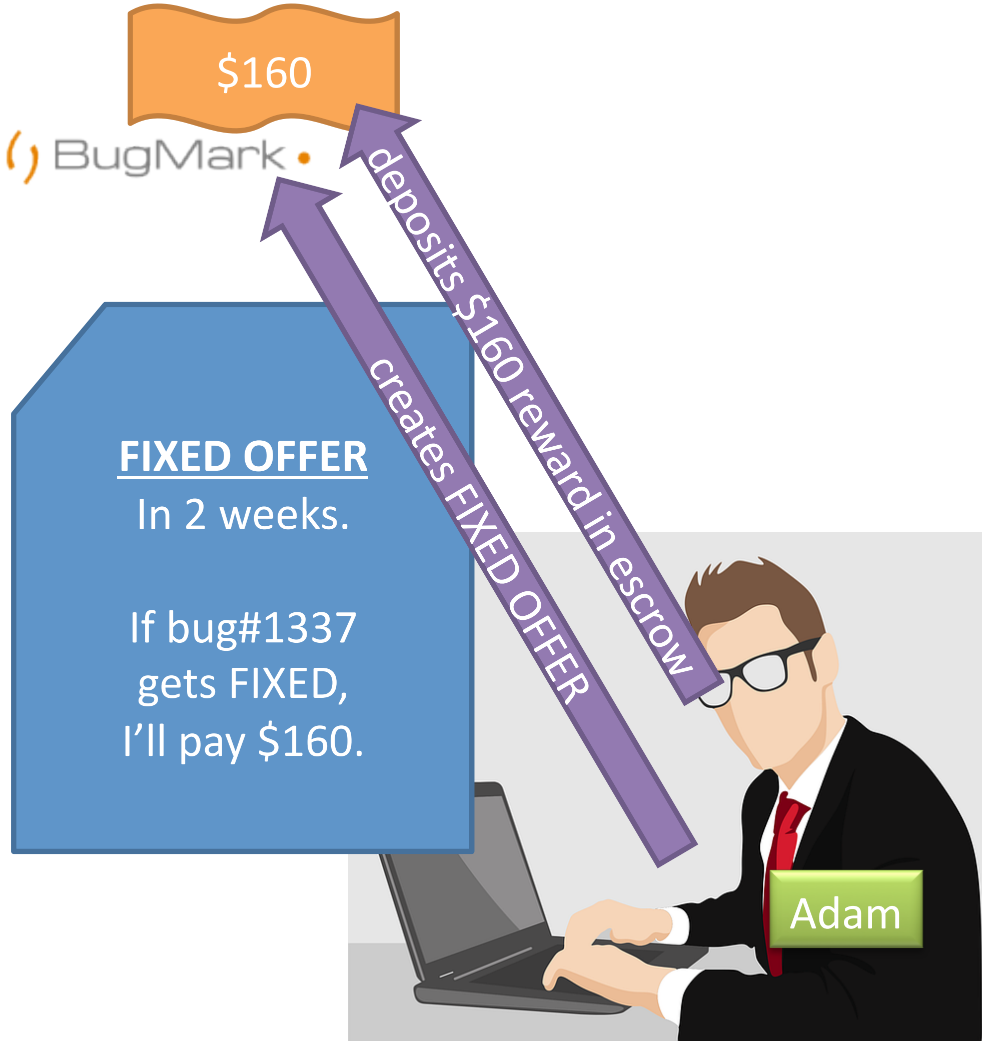
Step 1: File or find a bug

- Before Adam can go to Bugmark, he has to make sure the bug is documented.
- Bugs are documented in an issue tracker.
- If no entry exists for this bug, Adam creates one.
- Adam's bug is identified as bug#1337

Courtesy Georg Link

Step 2: Offer to pay for the bug fix

- Adam goes to Bugmark and offers to pay for the bug fix
- Adam creates a FIXED OFFER with a maturation date in 2 weeks for a payoff of $200
- Adam buys 200 units at a unit price of $0.8, paying $160



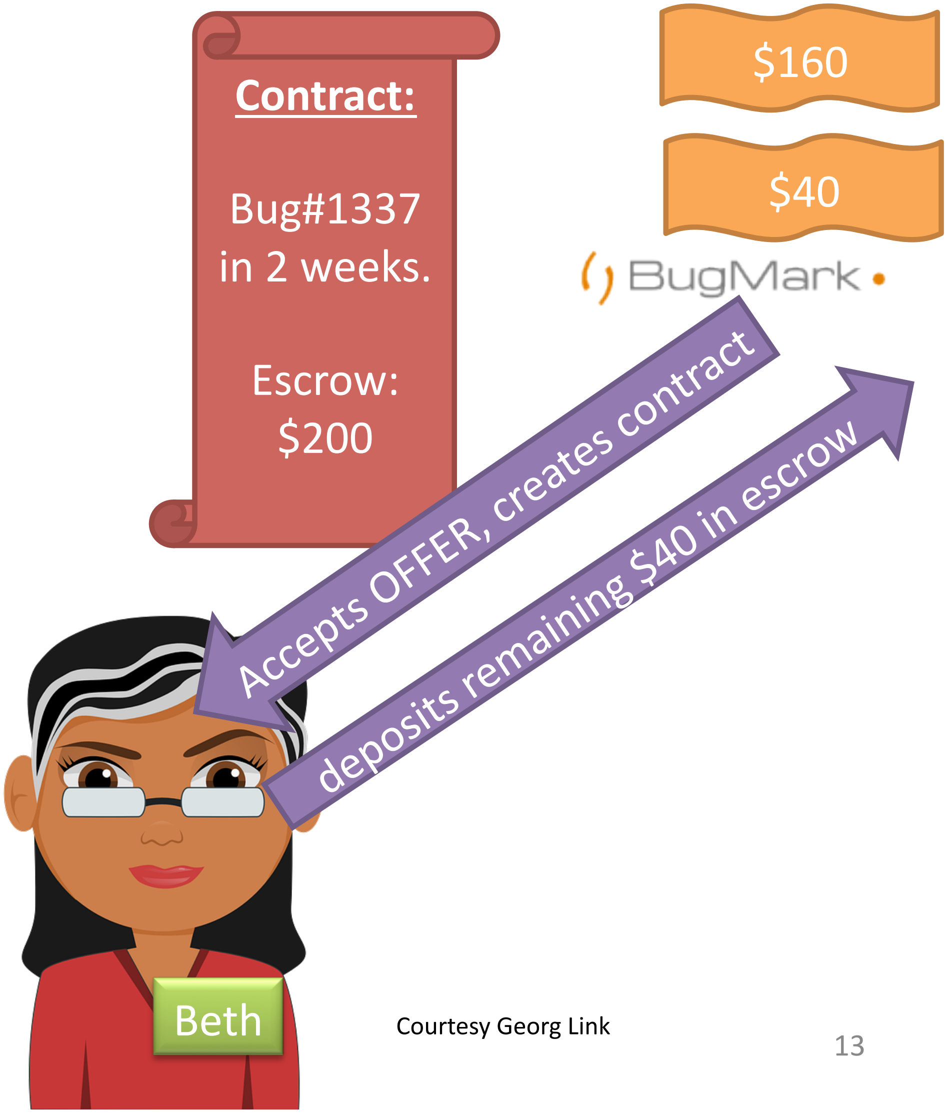
FIXED OFFER
In 2 weeks.

If bug#1337 gets FIXED, I'll pay $160.

Courtesy Georg Link

Step 3: Developer accepts FIXED OFFER

- Developer Beth sees the FIXED OFFER, has time to fix the bug within two weeks, and decides to buy the FIXED OFFER
- Beth buys 200 units at a unit price of $0.2, paying $40
- Contract is formed



Contract:

Bug#1337 in 2 weeks.

Escrow: $200

$160

$40

BugMark

Accepts OFFER, creates contract

deposits remaining $40 in escrow

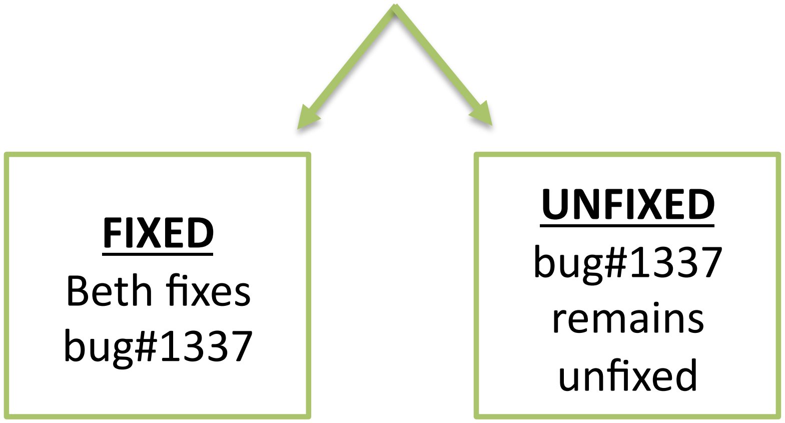
Beth

Courtesy Georg Link

Step 4: Two weeks pass

- Adam is waiting
- Beth is developing

- Two possible outcomes



FIXED
Beth fixes bug#1337

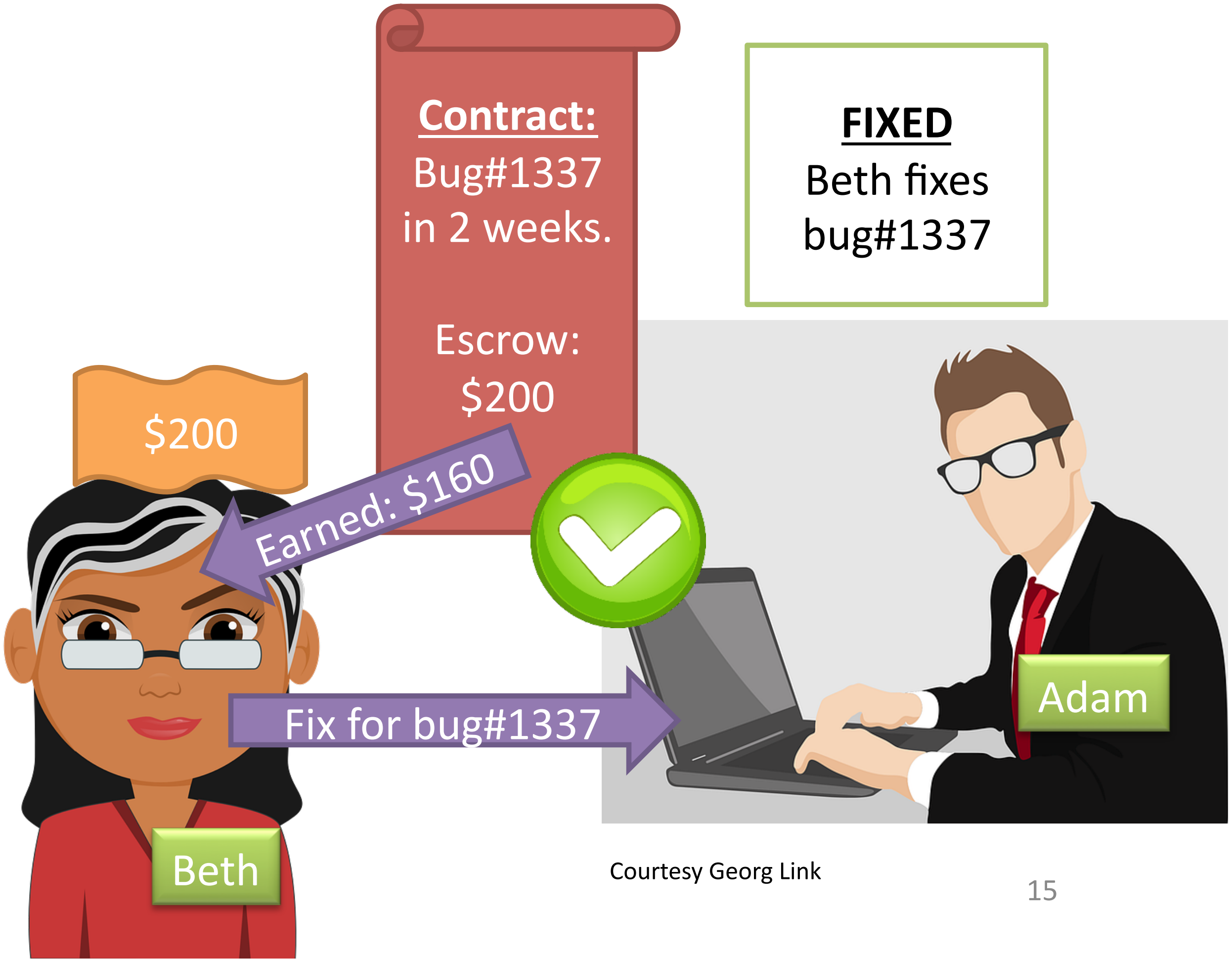
UNFIXED
bug#1337 remains unfixed

Courtesy Georg Link

Outcome: FIXED

- The issue is closed
- Beth earns the reward of $160 and gets her $40 deposit back
- Adam receives the fix and pays with his deposit

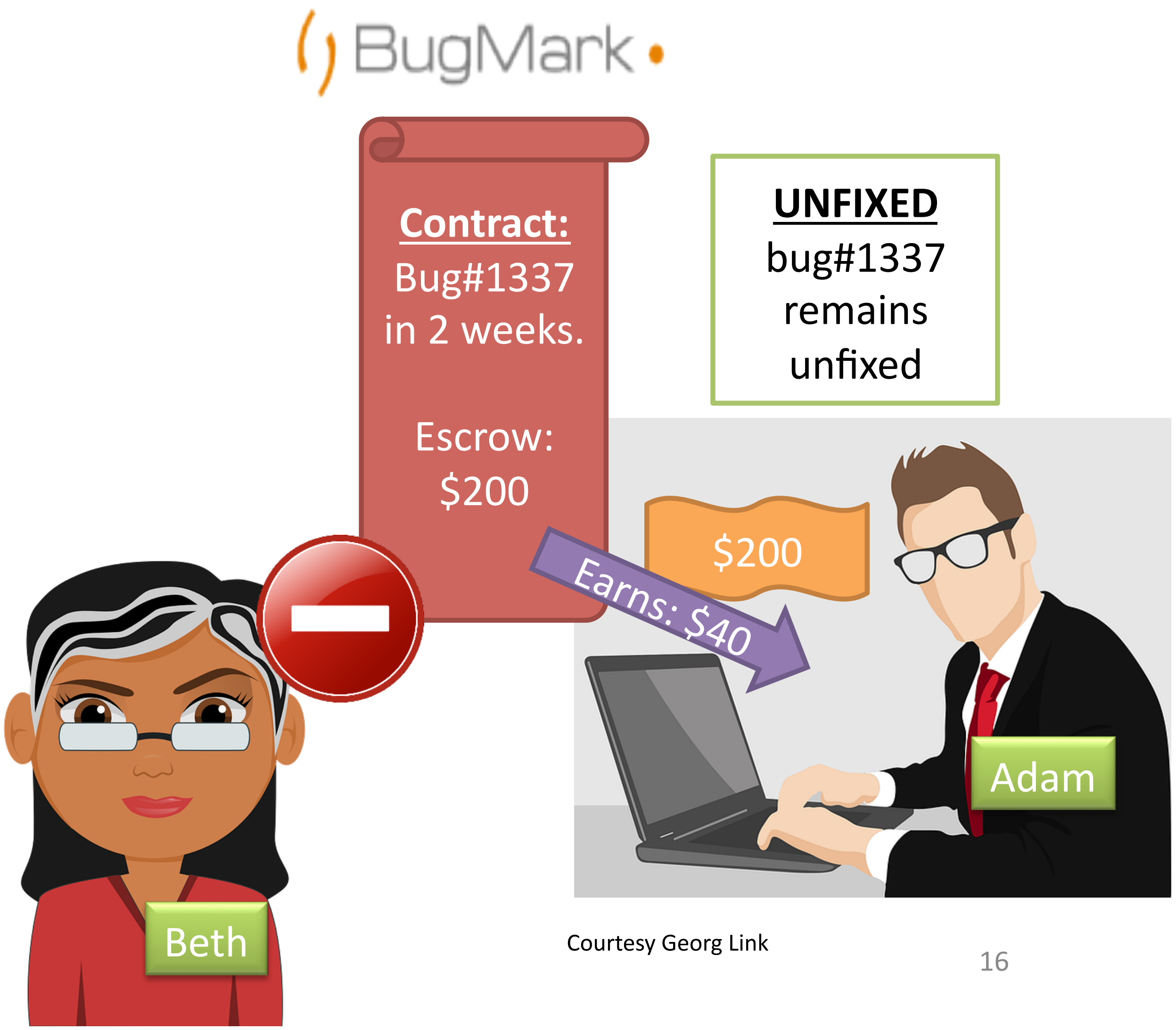
BugMark



Courtesy Georg Link

Outcome: UNFIXED

- The issue is open
- Beth loses her $40 deposit
- Adam receives his and Beth's deposits: earns $40



Contract:
Bug#1337
in 2 weeks.

Escrow:
$200

UNFIXED
bug#1337
remains
unfixed

Courtesy Georg Link

Design features

- Partial work
- Dependencies
- Indemnity
- Decoupling funding from work
- Multiple contracts

Our approach

- How are we different from existing systems?
  - Bounty systems: typically reward the submitter of the final solution. But development is often done in a collaborative way where work layers on previous work [Howison and Crowston 2014]. Tasks may also require different skills. Need a way to assign credit to various contributors involved in a solution.

    Trading market allows users to do partial work on a contract and then resell their positions.

Our approach

- How are we different from existing systems?
  - Prediction markets: small number of tradable questions but a large number of participants ("wisdom of the crowd").

    We have a large number of futures contracts but a small number of participants per tradable task ("wisdom of individuals" revealed to crowds of software users).

    Participants have information about the issue and can influence the outcome.

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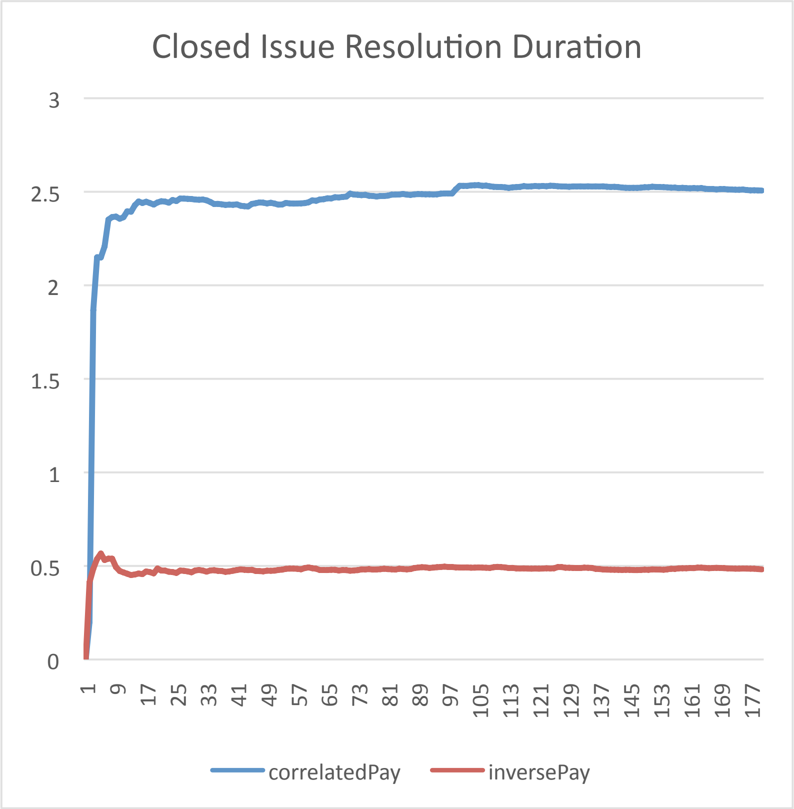
Simulation

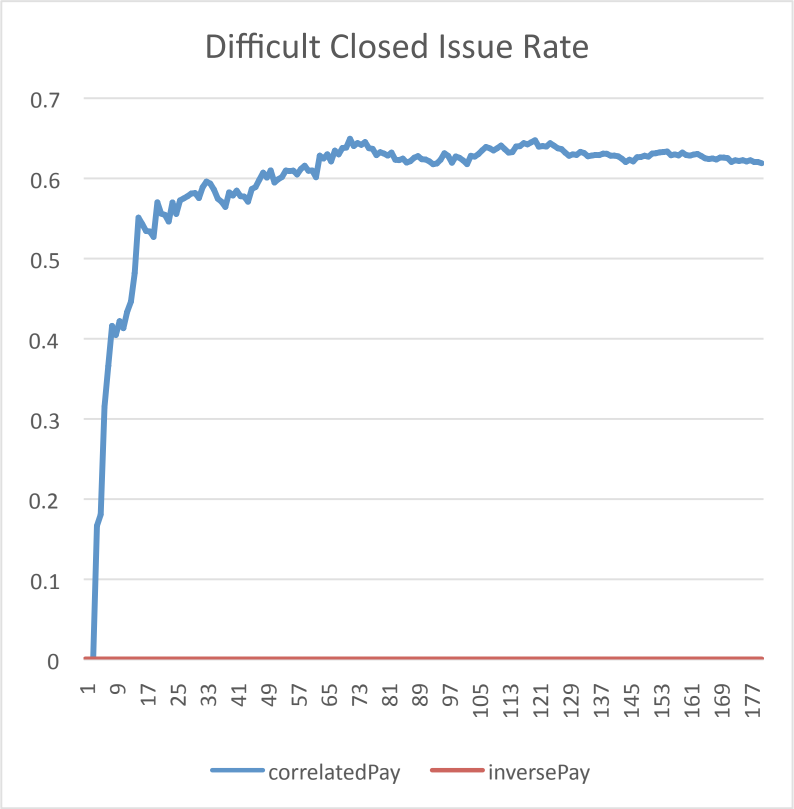
- **2** funders each owning a project: **correlatedPay and inversePay**
- **10 workers** use price signals to choose issues.
- Each day, **each funder generates 10 new issues** and an accompanying offer that **matures after three days**.
- Issues are randomly assigned a **difficulty level of 1, 2, or 3** (1/3 probability each) which indicates how many days it takes for a worker to finish the issue. Every issue has **40% chance to require 1 extra day** to finish.

Simulation

- **Unit prices are 0.9, 0.8, and 0.7 tokens.** CorrelatedPay offers higher prices for more difficult issues (i.e., 1 -> 0.7, 2 -> 0.8, 3 -> 0.9). InversePay offers higher prices for easier issues (i.e., 1 -> 0.9, 2 -> 0.8, 3 -> 0.7).
- Every offer is for the **volume of 100 units and pays out 100 tokens**. The price for a buy unfixed offer of 0.9 means that the funder pays 90 tokens and the worker 10 tokens.
- The simulation **runs for 180 days and is repeated 5 times**. Values presented are averages over all 5 runs.

Simulation results





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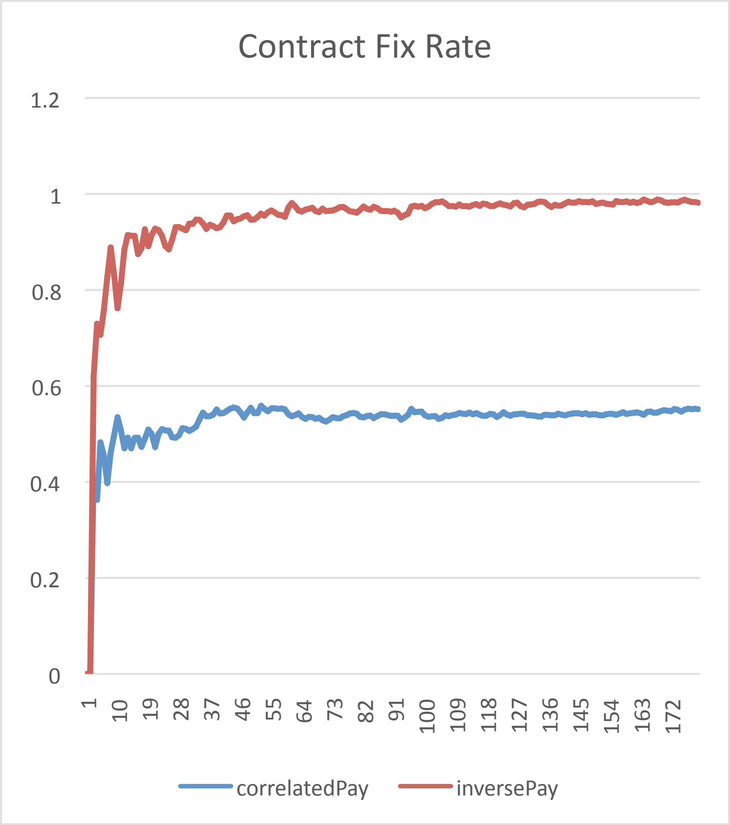

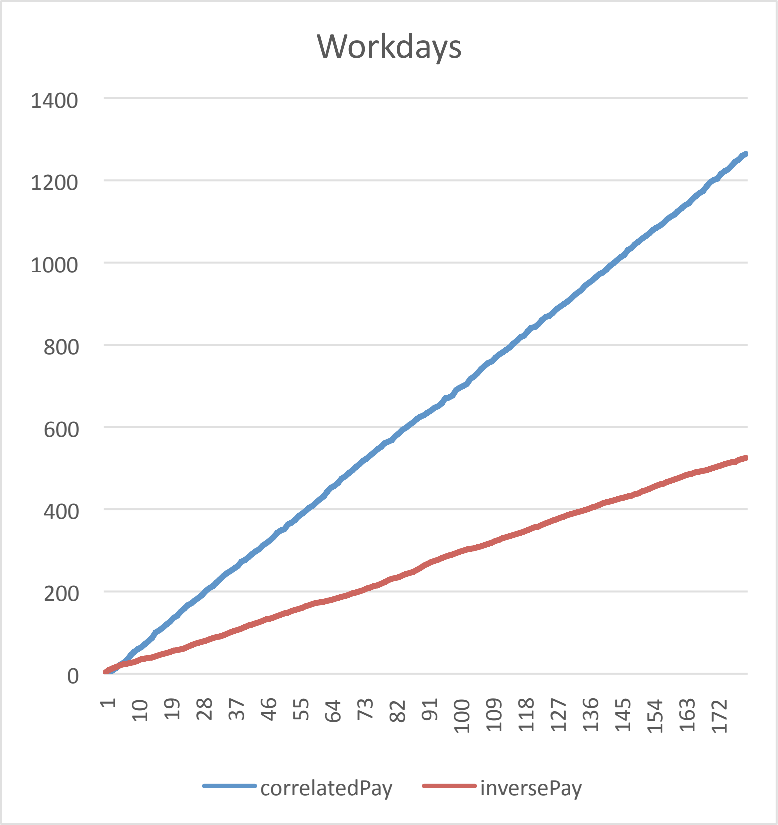

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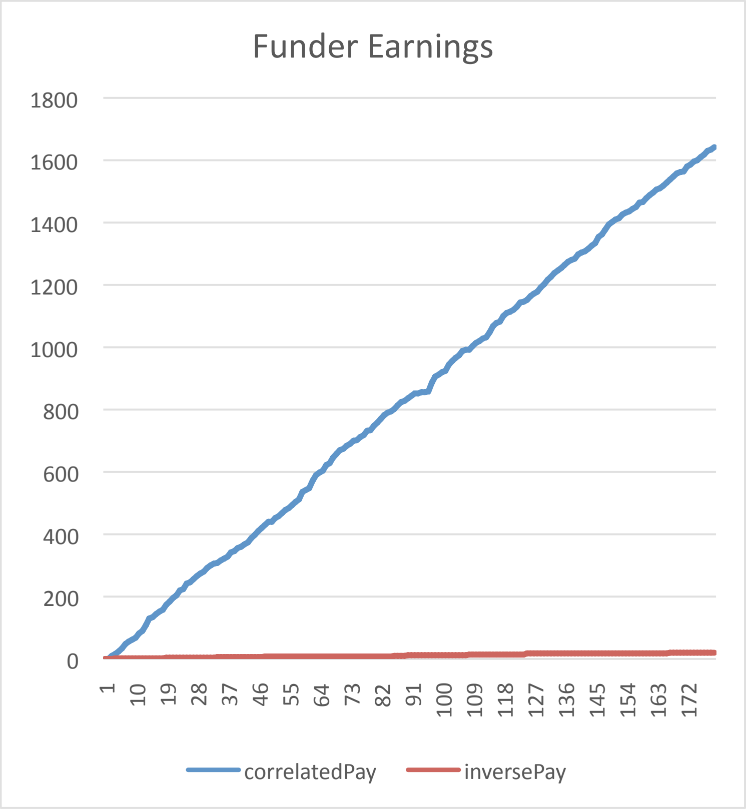

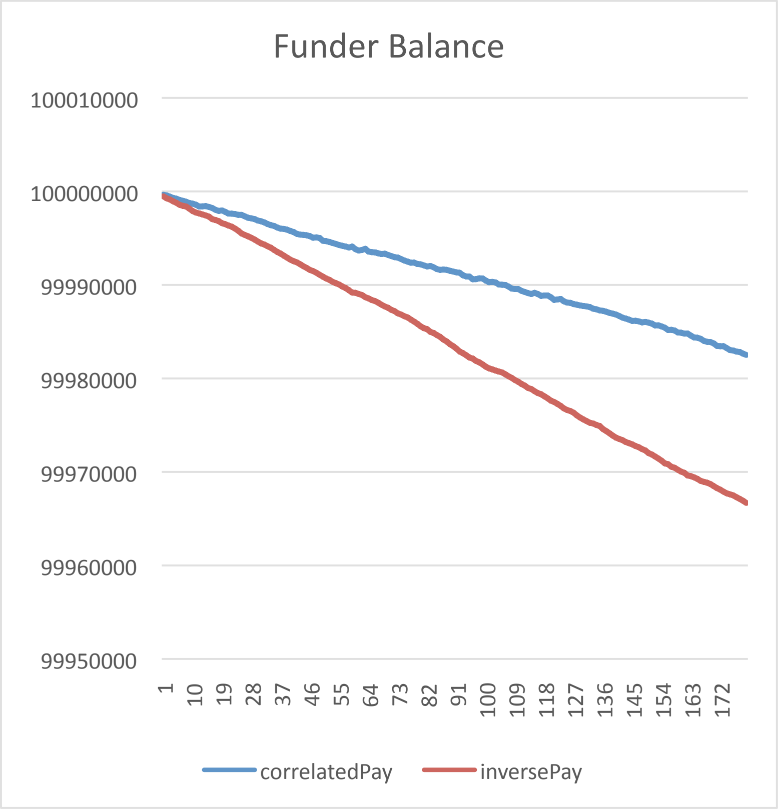

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Ongoing and future work

- What are the consequences of introducing price signals in peer production?
- How does this model compare to other market models?
- Scope of futures markets and their application to the contract design.
- Interaction of market with current secure software engineering practices

Ongoing and future work

- How can such a system work alongside other diverse motivations to contribute?
- How to incentivize project maintainers and reviewers, incorporate testing, verify work is done correctly?
- Lots of experiments and data needed
  - Completed live worker-funder-trader usability study
  - More simulations and studies to follow
  - Collaborations welcome

Conclusion

- A futures trading market to incentivize software tasks in peer production communities
- Market design that introduces price signals in a way that leverages some of the successful qualities of peer production
- Credit for partial work enables information sharing and collaboration
- The market treats a prediction that something cannot be done in the same way as an incentive to make it happen

Thank you

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