Seminar “Ausgewählte Beiträge zum Software Engineering”

Tools for Capturing Micro-Process Data

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Talk overview

1. Utilizing micro-processes for defect prevention
2. Tools for capturing micro-process data
    1. Hackystat
    2. PROM
    3. Ginger2
3. Research tasks

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Micro-process: Definitions

- "*Micro-process*" in software development
  is the process view (i.e. series of events)
  of actions and activities (i.e. the events)
  taken by a software developer or developer group
  while performing a specific sub-task.
  - Work psychology: "Activity analysis"
  - First we focus on coding as a sub-task for a single developer
- "*Capturing micro-process data*" means taking a log of time-stamped events
- "*Episode*" is an abstraction of a micro-process' time interval which forms a typical series of events
  - Similar to "Pattern"
- "*Situation*" are conditions of the task and environment
- "*Belief*" is a worker's knowledge about domain and action

Coding micro-process: Examples

- Events
  - typing, executing code, browsing doc., saving file
  - picking up phone, conversation, going to lunch, pausing
- Episodes
  - trial-and-error, copy-paste-change
  - resuming work after interruption, stack of working tasks
- Situation
  - task description, previous events, used tools, noise
  - workload, stress, tiredness, intelligence, experience
- Beliefs
  - language semantics, design decisions, library usage, requirements, used quality criteria, division of labour

Utilizing micro-process for defect prevention

- "*Defect*": Structural property of a software document that makes it (locally) incorrect
  - ?? Any part of a software document which has later been changed, added or removed permanently ??
- "*Defect insertion*" is the action of creating defective code
  - Hypothesis: An (episode, situation, belief)-triple is associated
  - The defect has a type (taken from a defect taxonomy)

- Research target: To find typical defect insertion triples
  - Correlation (e,s,b)-triple to defect type
  - ... or to present a reason why there are none
  - in general: understanding defect insertion better

Other opportunities while collecting m.p. data

- When X was an defect insertion, ~X may be also
- Tracking evolution of code copies
- "Macro-fying" work episodes
- Suggest places to look at because of past browsing sessions
- Aid for empirical research on psychology of programming
- Re-examining past coding sessions
  - summary possible?
  - learning about personal bad practices
  - learning from colleagues
- Evaluating new micro-process metrics
  - e.g. discriminating novices from experts

Capturing micro-process data

- Capturing micro-process data focuses on the episode part of the triple.
- Possible data sources are
  - programming environments
  - work environment devices (e.g. phone)
  - other indicators of what the programmer is actually doing
- We need a tool which should be
  - able to collect interesting events
  - ... automatically (via instrumentation of data sources)
  - able to compile episodes
  - non-disruptive
  - usable in realistic scenarios
  - extensible to a variety of data sources

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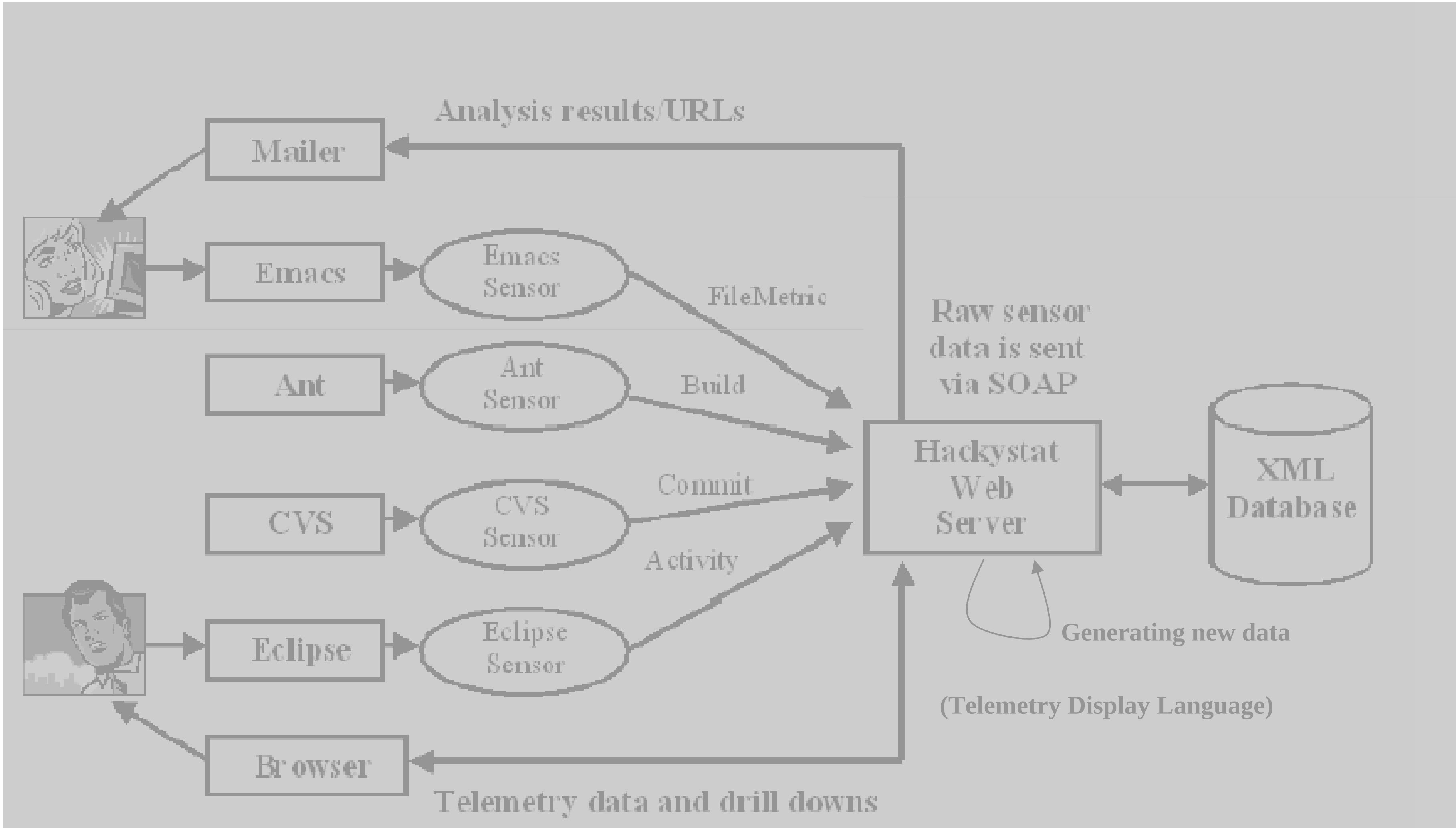
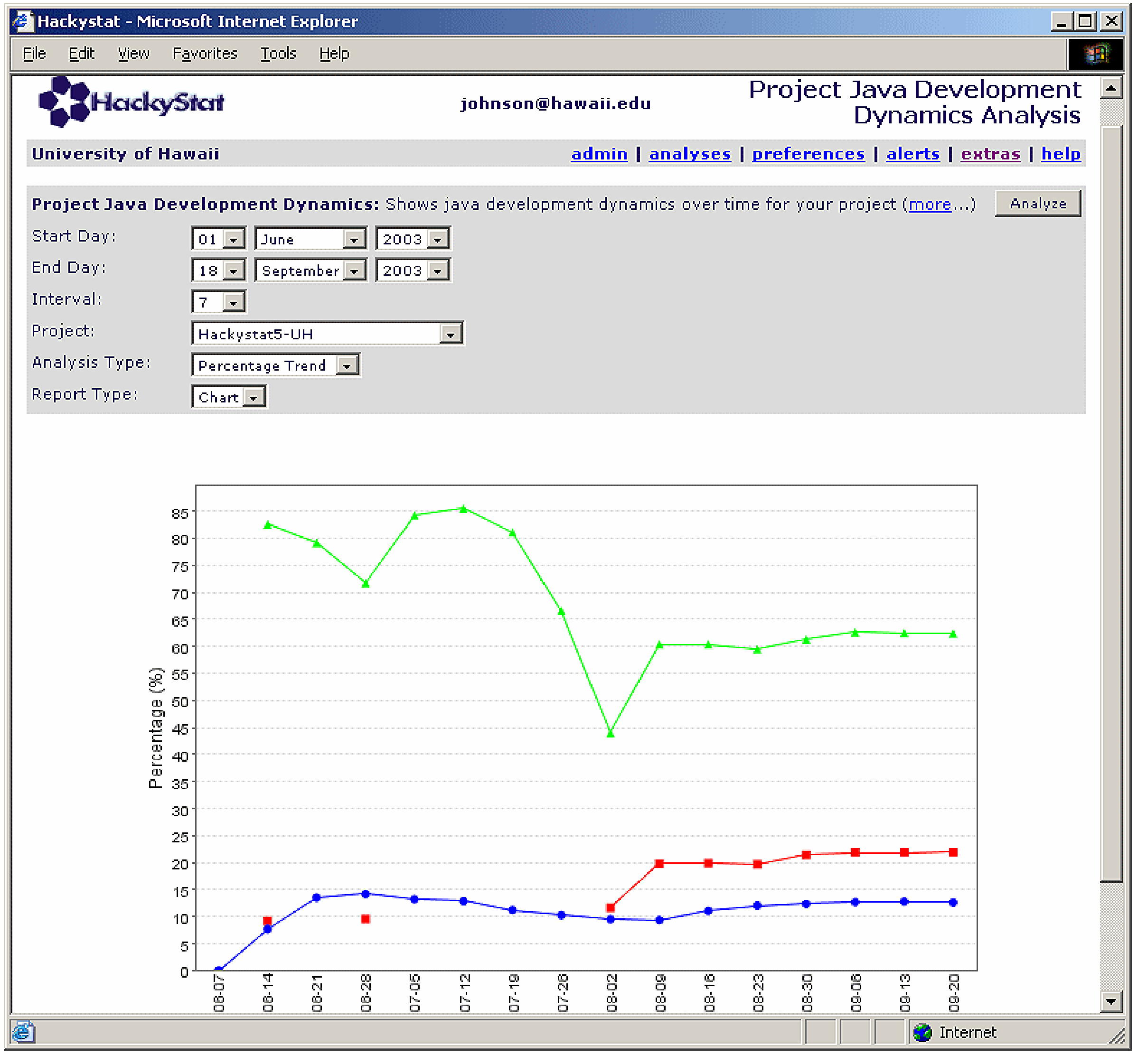
Hackystat – Its origin

- Prof. Johnson at University of Hawaii
- Started with some PSP tools for easy logging of defect and effort data
- “You can’t even ask them to push a button”
  - Automatic collection is a must
- Developing Hackystat since ?, available since 2001.
- New story: Software Project Telemetry

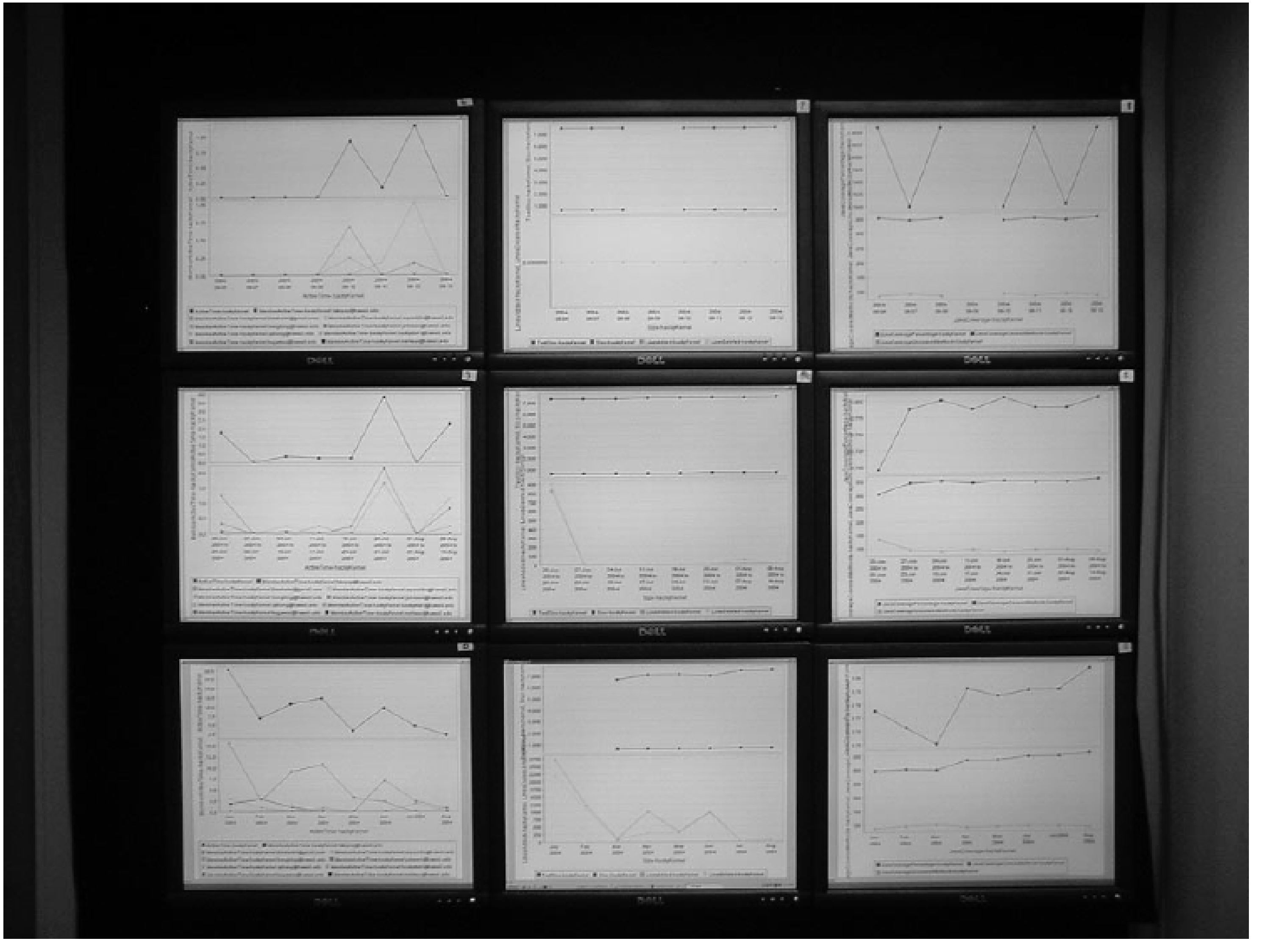
Hackystat architecture



Hackystat Web interface



Hackystat: Telemetry Control Center



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Hackystat: Telemetry – what for?

- Telemetry: “communications process for measuring, monitoring and recording using data collected at inaccessible points”
- Software Project Telemetry requirements
  - automatically
  - stream of time-stamped events
  - immediately available
  - even if measurement started midway through a project
  - in-process monitoring, *in vivo*
- Development telemetry
- Build telemetry
- Execution telemetry, Usage telemetry
  - not our focus

Hackystat: Sensors and Events

- Sensors are “plug-ins” to send data to Hackystat server
  - tool specific
  - data specific
- Emacs, Visual Studio, JBuilder, Eclipse
  - Activity, BufferTransitions, FileMetric
  - Build, UnitTest
- Excel, Word, Powerpoint, Frontpage
  - Activity, BufferTransitions, FileMetric
- Command line
- JUnit
  - UnitTest
- Ant, CVS, Bugzilla
  - Commit, Defect, Build

Hackystat: Events in Eclipse

- Eclipse-Events (as of version June 2004)
  - Project open/close
  - (Java) file open/close/save/activate/change (with file metrics)
  - Breakpoint add/remove
  - Compiler errors
  - Class add/delete/move
  - Method and Attribute add/delete/move
  - Import add/remove
  - JUnit-Run failures/errors
  - Runtime failures
- No code change analysis
- Local buffering of events

Hackystat: Metrics

- Derived metrics:
  - Usage times of a tool
  - Working time of developer
  - Size/lines of files
  - Build attempts per project
  - Number of failures per module
  - Coding time per module
  - Defect frequency per module
  - Complexity of module
  - etc.
- module = set of files

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Hackystat: Design

- Completely Java-based (apart from some sensors)
  - CVS, Ant, JUnit, HttpUnit, JSP, Tomcat, JDOM, Cruise Control, JFreeChart
  - No database, XML data plain file.
- Open-Source
- Modular Ant build process
- Lots of unit tests
- Easy installation (apart from sensors, SOAP setup)
- In 5th architectural revision
- Funded by: Sun, IBM, NSF, NASA

Hackystat: Can we use it?

- Events are not fine-grained enough
  - Events are file operation based (open, save)
  - We probably need code changes without file change
- Server and Communication *reusable*
  - No database: scalability?
  - XML representation just fine?
- Sensor data types *reusable* as well
- Different analysis tools necessary
  - Events analysis
  - Episode analysis
  - Defect detection

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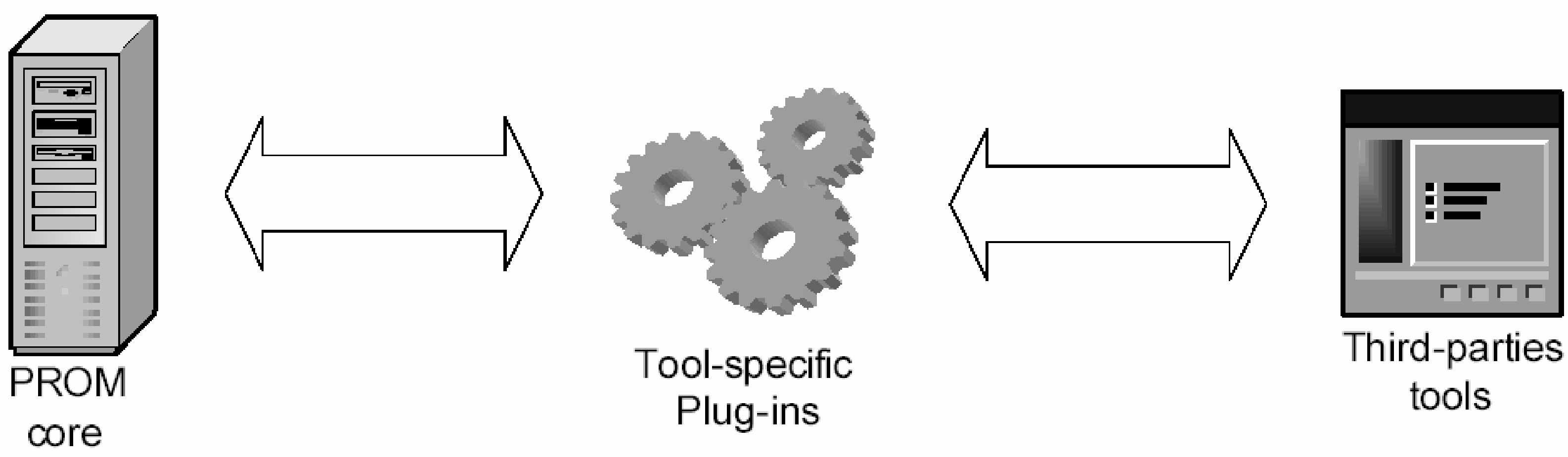
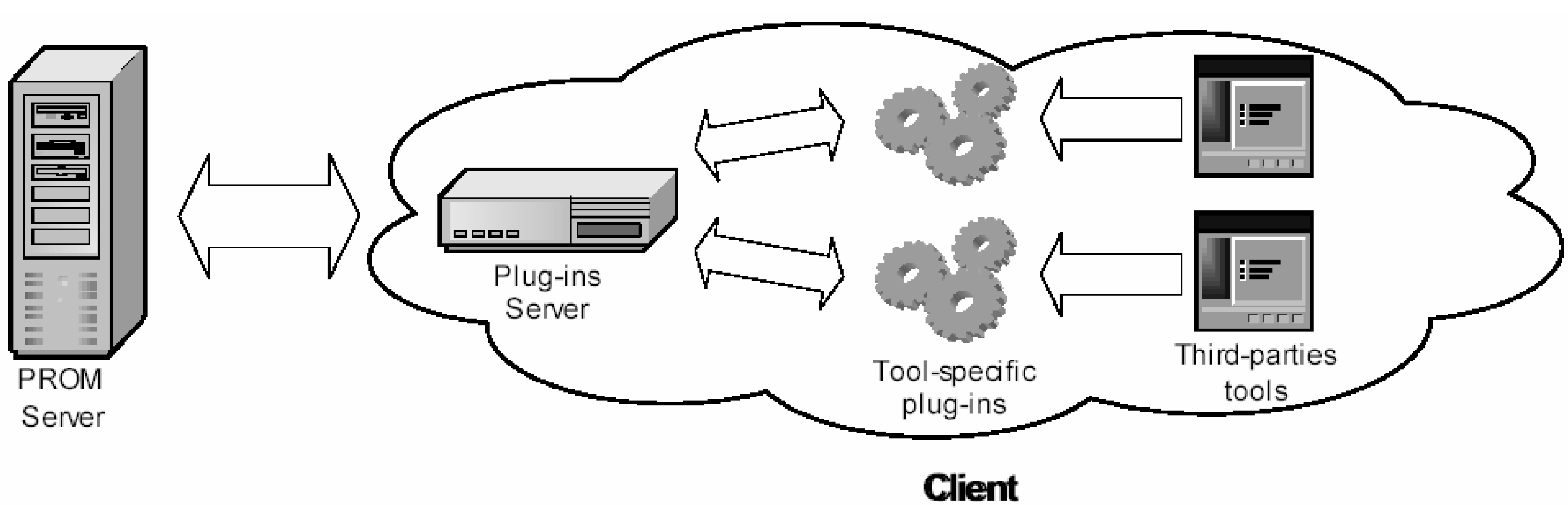
PROM: Its Origin

- PROM = PRO Metrics
- Universities Bozen and Genova, Italien
- Also PSP-based research, mainly time estimation

- Only little information, still alive?

PROM: Architecture





PROM: Plug-ins and metrics

- Plug-ins
  - NetBeans, Eclipse, JBuilder, Visual Studio
  - Together, Rational Rose
  - MS Office, OpenOffice
- Events/Metrics
  - Users logged in
  - Project name
  - Class name
  - File opening
  - Focus time
- More information not available

PROM and Hackystat

- PROM claims to be more general than Hackystat...

- Manual data insertion possible
- Plug-in server
- Database

- No Open-Source (?)

⟹ Nothing (real) new

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Ginger2: Its Origin

- Nara Institute of Science and Technology, Japan
- Prof. Torii, Dr. Mondon

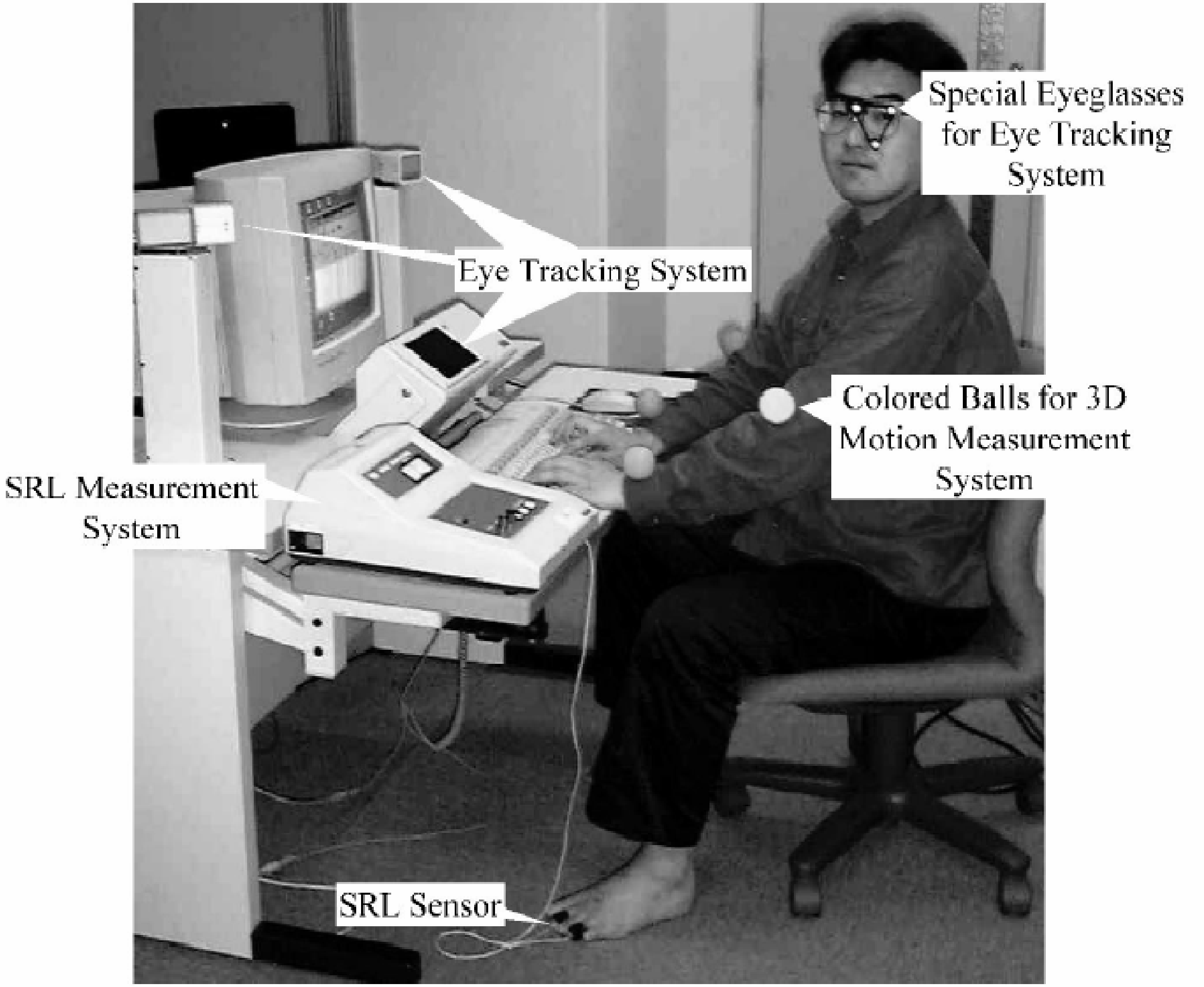
- Following based on TSE paper 1999
- No (readable) information on web site

- CAESE: Computer Aided Empirical Software Engineering
  - repeatable experiments
  - computer based data collection
  - automated data analysis
- Laboratory environment for *in vitro* studies

Ginger2: Experimental environment

Giner2 measures.

- eye tracks
- skin resistance
- motion
- audio
- video
- typed keys
- tool usage
- file changes



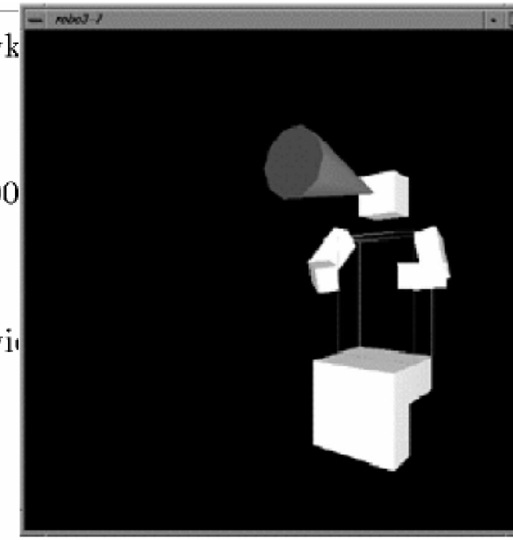
By the way: Pupillometry

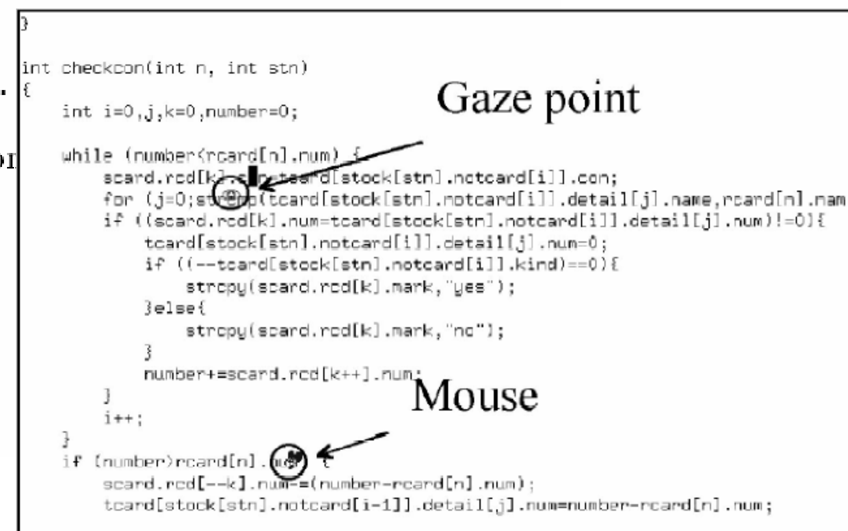
- Size of worker's pupil
  indicates mental workload
  - stress
  - difficult tasks
  - etc
- Not used by Ginger2
  but used by Center for Media Research, FU Berlin
  - to control computer-based learning sessions

Ginger2: Data display

h hawk	# The following event occurred on a computer called hawk
:739713873	# The following event occurred at 739713873 seconds.
w 0x380000c	# The following event occurred on a window called 0x3800
Wo 400x200+100+100	# A window was opened.
Ts 20 14	# The height of a text line is 20 dots and the character wi
T hawk%_0 0	# The prompt “hawk%” was displayed.
C 6 0	# A text cursor appeared.
:1.5	# 1.5 seconds has passed.
K cd_/etc\r	# The command “cd /etc” was input.
T cd_/etc	# “cd /etc” was echoed at the locatior
T hawk%_0 1	# The next prompt is displayed.
C 6 1	# The cursor has moved.
:3	# 3 seconds has passed.
K ls_r	# The command “ls” was input

(Ginger1 log)





Ginger2: Case studies 1-3

- Case study: Debugging process of experts and novices
  - used eye tracking and audio/video
  - Findings:
    - Experts focus on one or two modules faster
    - Novices shift their gaze points rapidly
- Case study: Understanding two-person debugging
  - used audio/video and terminal logging
  - different types of communication observed
  - Findings:
    - asynchronous communication (chat, mail) is more effective than synchronous (verbal) communication
    - division of work is effective: one “understander”, one “locater”: uni-directional communication
- Case study: Evaluation of user interfaces

Ginger2: Case study 4 (1)

- “Analysis of programmer’s behavior when creating bugs”
- Technical report in Japanese, 1994
- Personal communication

- Used Emacs logging, audio/video
- Planned: eye tracking
- Defect detection via unit tests

- 3 subjects, 42 defect insertion
- Subjects coded unit tests as well

Ginger2: Case study 4 (2)

- 6 patterns extracted (written as a grammar)
  1. Copy-Paste-Change
  2. Badly resuming work
  3. Changing a line again and again
  4. Overseeing the second of two defects in one line
  5. Writing a line for a long time
  6. Copying a defective line
- Half of the defects can be described with any one of the patterns
- Overall: 1% probability of defect per line
- Pattern 1 observed => 7.5% pb. of defect insertion
- Pattern 5 observed => 10.5% p.o.d.i.

Ginger2: Summary

- Disruptive environment
- Not “off the shelf”
- No ongoing work (?)

- The only micro-process analysis towards defect prevention I’m aware of
- Non-promising initial results

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Micro-process research tasks

- Learning about programming models
- Defining a set of interesting events and episodes
  - mainly exploratory work
  - grammar just like in Ginger2
  - episode extractor
- Developing an Eclipse plug-in to capture micro-process
  - reusing Hackystat as a server
- Establishing ways to isolate defects
  - micro-process changes, analysing code rev., bug report
- Capturing data (a lot)
- Analysing the data
- Investigating *situations* and *beliefs*
  - using psychologist’s research on human error

Thank you!