Software Development at Microsoft

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The Real World Challenge

Code on a massive scale

Developers on a massive scale

Tight constraints on schedules
What We’ll Talk About Today

- Company structure
  - Why the world is not just about developers 😊
- Innovation strategy
  - How we actually improve software over time
- Dynamic tension
  - When people are involved, everything changes
- Development cycles
  - How we build software products in cycles
- Program analysis
  - How we push quality upstream
- Windows engineering system
  - How we build large-scale products
Core Disciplines @ Microsoft

- Total size: ~89,000 employees
- Windows & Office – “perfect org structure”
  - PM – program managers
  - Dev – software developers
  - Test – software developers in test
- Around 1000 PM+Dev+Test feature teams on 100s of products
Windows Division

- Team size: ~10,000 employees
- Sales & marketing
- Project managers / product managers
- 30 feature teams
  - 1500 Devs
  - 1500 Testers
  - 1000 PMs
- Customer support engineers
- Build engineers
Software– Art or Science?

“I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the state of Science, whatever the matter may be."

– Lord Kelvin, 1883
Virtuous Feedback Loops

- “A complex of events that reinforces itself through a feedback loop”

- Once you have measurability and virtuous feedback, you get incremental improvements

- Examples
  - SQM data, usability testing, Windows Error Reporting, static analysis, code coverage, test reports, annual reviews, product reviews
Product Design

- Identify customers and their requirements/problems/values
- Describe compelling visions for the product
- Establish tenets that act as product themes to support the visions
- Describe the scenarios that enable tenets
- Create features that embody the solutions
- Iterate features based on virtuous feedback
Dynamic Tension

“The actual process is fluid and evolving…”

- Thought leader: Dev / Test / PM
- Version focus: features vs. bugs
- Design agility: waterfall vs. scrum
- Capacity allocation: design/coding/debugging
- Open source: Cathedral vs. Bazaar
Thought Leaders

- Which form of leadership?
- All teams are organized / led differently
  - PM driven – best for end user visible shipping features / products
  - Dev driven – best for research / highly technical projects
  - Test driven – best for sustaining engineering
- Teams tend to evolve as the products / features mature
Version Focus

- How innovative should we be this time?
  - Focus on features
    - Usually results in new value but weak quality
  - Focus on bugs
    - Usually results in great quality but not interesting
  - Reaching a balance
    - Your customers will tell you which they want
Design Agility

- Scale of feature iteration?
  - Waterfall model
    - Planning occurs upfront years in advance and is often way off base by the end of the project
  - Scrum model
    - Planning occurs every 6 weeks and everything is delivered in small, short sprints with immediate feedback
    - May only work well for smaller features/products
  - Hybrid solutions
    - Planning occurs every 5 months and after each milestone customer feedback is received when major components are completed and integrated
Capacity Allocation

- Where do you spend your time?
  - Design – OOD, factoring, architecture, algorithms
  - Coding – producing source, writing unit tests, TDD
  - Debugging – debuggers, running tests, fixing bugs
- Some typical allocations
  - OOD: 60% design, 20% coding, 20% debugging
  - Classic: 40% design, 20% coding, 40% debugging
  - Agile: 20% design, 30% coding, 50% debugging
- Most sub–teams will vary their approach
Open Source

- Who controls the code?
  - Cathedral – High priest owns the scripture
    - This is the classic one person owns each binary approach used industry-wide by many companies
  - Bazaar – everyone can join in
    - This is the approach used by most non-profit organizations where any can contribute
  - Public vs. private variants
    - It’s possible to do “open source” inside a company where it’s still private, but jointly developed by all
Concentric Feedback Loops

1. Product cycle – years per release
2. Outer loop – months per milestone
3. Middle loop – days per feature
4. Inner loop – minutes per compilation
Product Cycle

- **Years/Release**
  - **Tools**
    - Project – schedule charts for tracking progress
    - Excel spreadsheets – for feature value analysis
    - Internal websites – for document management
    - SQM product data – for customer usage data
    - Customer feedback – qualitative & quantitative data
  - **Roles**
    - Sales, marketing, Dev/Test/PM, doc, support
  - **Deliverables**
    - Requirements/pillars/tenets, Beta/RC/RTM bits, packaging, docs/kits, sales/marketing campaigns
Outer Loop

- Months/Milestone
  - Tools
    - Team Foundation Server (TFS) – feature tracking
    - Automated testing – functional tests
    - UX usability testing – live customer tests
    - Product Studio – bug database
  - Roles
    - PM/Test/(Dev)
  - Deliverables
    - Product features, product metrics, quality reports
Middle Loop

- Days/feature
  - Tools
    - Product Studio
    - Unit testing
    - Email discussion
    - Architecture/design/test documents
  - Roles
    - Dev/Test/(PM)
  - Deliverables
    - Bug fixes, code reviews, binaries, test runs
Inner Loop

- Minutes/Run
  - Tools
    - Source Depot – manage code versions
    - Visual Studio – compile/link/run
    - Static analysis – verify written code
    - Unit tests – verify basic functionality
  - Roles
    - Dev/(Test)
  - Deliverables
    - Running code, working tests
Windows Development Toolset

- Visual Studio – write, edit, compile, debug source code
- Team Foundation Server – track product features & tasks
- Source Depot – code changes and source branches
- Product Studio – defect reporting database
- Static analysis – detect code defects at compile time
- TAEF – software unit test framework
- Code coverage – verify completeness of testing
- Application Verifier, Driver Verifier – detect API misuse
- Scalable code search – Windows: 5K binaries, 1M functions, 100M lines
- Build machines – daily builds on hundreds of source branches
- ...
What I Wish Someone Would Have Told Me

- Actual productive development hours in an 8 hour day are very, very few; don’t be surprised at the overtime
- You need to learn 20% new technology per year just to stay even with the rate of change
- Software engineers are always too optimistic about schedules, particularly new ones; double or triple your estimates
- Devs stay at a small to medium software company with an average of 24–30 months; you will be moving around a lot
- Revenue per employee is crucial: <$200K doom; $200k–300k OK; >$300K great
- Be sure you pick a product & company you care deeply about
Good design + analysis tools + sound engineering process

Significantly fewer code defects
Push Quality Upstream Matters
Microsoft Source Code Annotation Language (SAL)

3,631,361 *

* number of annotations in Windows alone

more secure and reliable products
What do These Functions Do?

```c
void * memcpy(
    void *dest,
    const void *src,
    size_t count
);

wchar_t * wmemcpy(
    wchar_t * dest,
    const wchar_t * src,
    size_t count
);
```
memcpy, wmemcpy

Copies bytes between buffers. More secure versions of these functions are available; see memcpy_s, wmemcpy_s.

```c
void *memcpy(
    void *dest,
    const void *src,
    size_t count
);

wchar_t *wmemcpy(
    wchar_t *dest,
    const wchar_t *src,
    size_t count
);
```

Remarks

memcpy copies `count` bytes from `src` to `dest`; wmemcpy copies `count` wide characters (two bytes). If the source and destination overlap, the behavior of memcpy is undefined. Use memmove to handle overlapping regions.

**Security Note** Make sure that the destination buffer is the same size or larger than the source buffer. For more information, see Avoiding Buffer Overruns.
Remarks

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Vital property for avoiding buffer overrun.
SAL Speak

void * memcpy(
    _Out_writes_bytes_all_(count) void *dest,
    _In_reads_bytes_(count) const void *src,
    size_t count
);

wchar_t * wmemcpy(
    _Out_writes_all_(count) wchar_t *dest,
    _In_reads_(count) const wchar_t *src,
    size_t count
);

✓ Captures programmer intent
✓ Improves defect detection via tools
✓ Extends language types to encode program logic properties
**Precondition**: function can assume `p` to be non-null when called

```c
_Post__Notnull__ void * foo(_Pre__Notnull__ int *p);
```

**Postcondition**: function must ensure the return value to be non-null

```c
struct buf { 
    int n;
    _Field_size_(n) int *data;
};
```

**Invariant**: property that should be maintained
Automated Program Analysis Tools

**Code Correctness**
Static tools – PREfix, PREfast, Esp

Detects buffer overrun, null pointer, uninitialized memory, leak, banned API, race condition, deadlock, ...

**Code Coverage**
Code coverage tool – Magellan (based on Vulcan)

Detects code that is not adequately tested

**Architecture Layering**
Dependency analysis tool – MaX (based on Vulcan)

Detects code that breaks the componentized architecture of product
We need to deal with partial programs and partial specifications.

Any of the inputs could trigger a bug in the program.
- No false negative—we have to try all of the inputs.
  If we do the inputs in bunches, we’ll have noise.
- No false positive—we have to try the inputs one by one.
  But the domain of program inputs is infinite.
**Dynamic Analysis**

Run the program.

Observe program behavior on a single run.

Apply rules to identify deviant behavior.

Example: Application Verifier

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**Static Analysis**

Simulate many possible runes of the program.

Observe program behavior on a collection of runs.

Apply rules to identify deviant behavior.

Example: PREfast
Local Analysis

Single-function analysis (e.g., PREfast)

Scales well enough to fit in compilers.

Example: unused local variable

```c
void foo(int *q) {
    int *r = q;
    *q = 0;
}
```

Global Analysis

Cross-function analysis (e.g., PREfix)

Can find deeper bugs.

Example: null dereference due to broken contract

```c
void bar(int *q) {
    q = NULL;
    foo(q);
}

void foo(int *p) {
    *p = 1;
}
```
Windows Build Architecture

Forward Integration (FI): code flows from parent to child branch
Reverse Integration (RI): code flows from child to parent branch
Local Analysis on Developer Desktop

Microsoft Auto Code Review (OACR)
- runs in the background
- intercepts the build commands
- launches light-weight tools like PREfast plugins
Quality Gates

Quality Gates (static analysis “minimum bar”)
- Enforced by rejection at gate
- Bugs found in quality gates block reverse integration (RI)
Global Analysis via Central Runs

Heavy-weight tools like PREfix run on main branch
Methodology

Root Cause Analysis

Measurement

Analysis Technology

Resource Constraints

Engineering Process

Understand important failures in a deep way
Measure everything about the process
Use feedback to improve the engineering process
Bottom Line Results

- From Microsoft annual report
  - Years in business – since 1975
  - Annual revenue – $62.484 B
  - Profit margins – 30.84%
  - Balance sheet – $39.98 B
  - Revenue/employee: $700K
Questions?