Identifying, Assigning, and Quantifying Crosscutting Concerns

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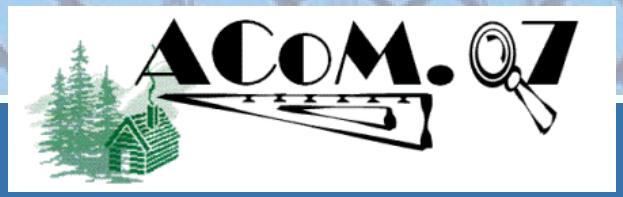
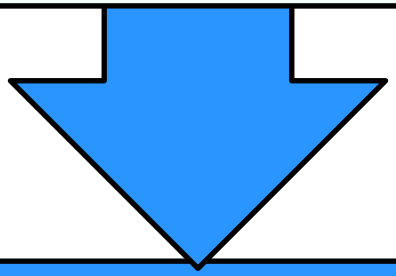


Motivation

Concern quantification is important, but current techniques are inadequate



Our Contribution

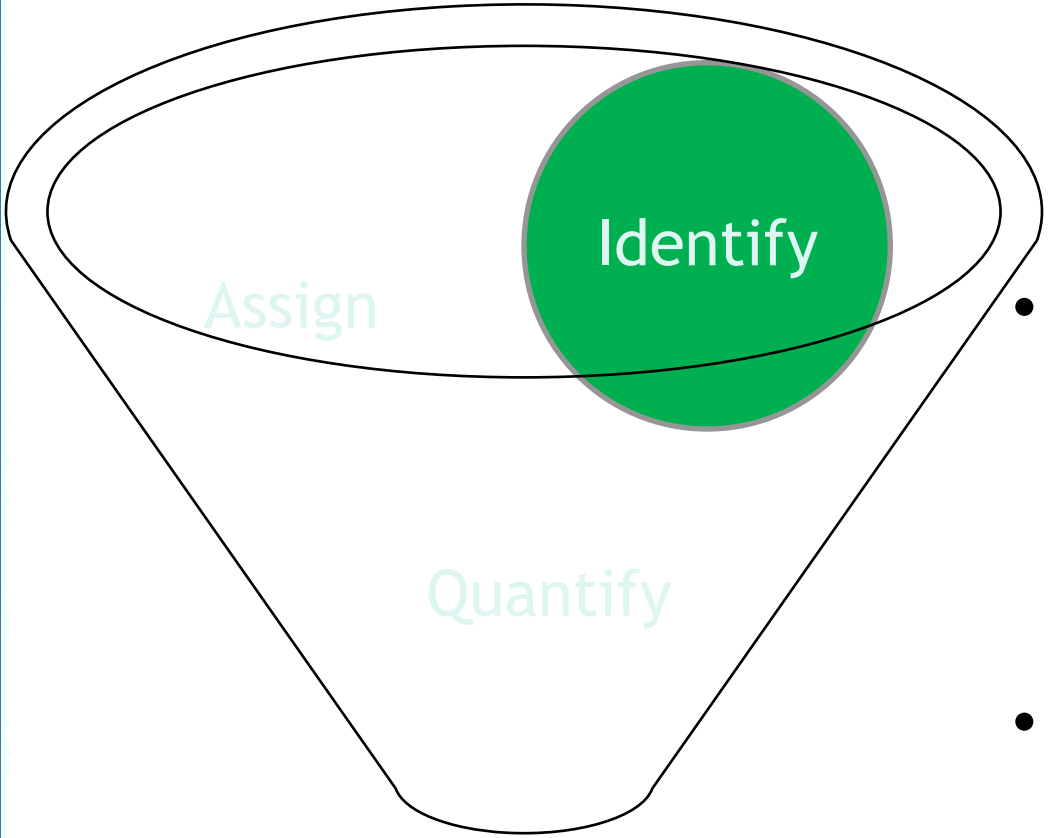
Improved manual technique for locating concerns	New concern metrics (DOS, DOF)

Concerns

Every line of code exists for a reason

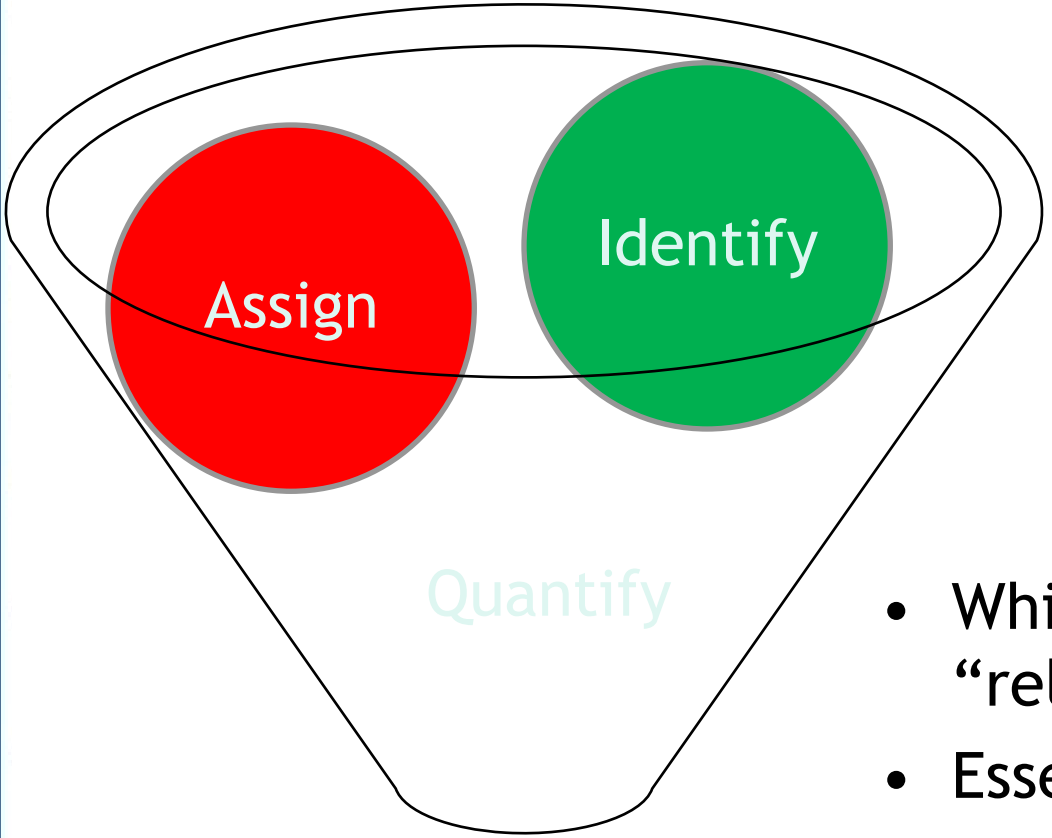
- Anything that impacts the implementation of a program
- Important to understand concerns…
  - "Why is this class/method/line here?"
  - Concerns are likely sources of change
- …and how they are implemented
  - Improves program understanding
  - Improves change impact estimation
  - Impacts software quality (e.g., defects)

Concern Analysis



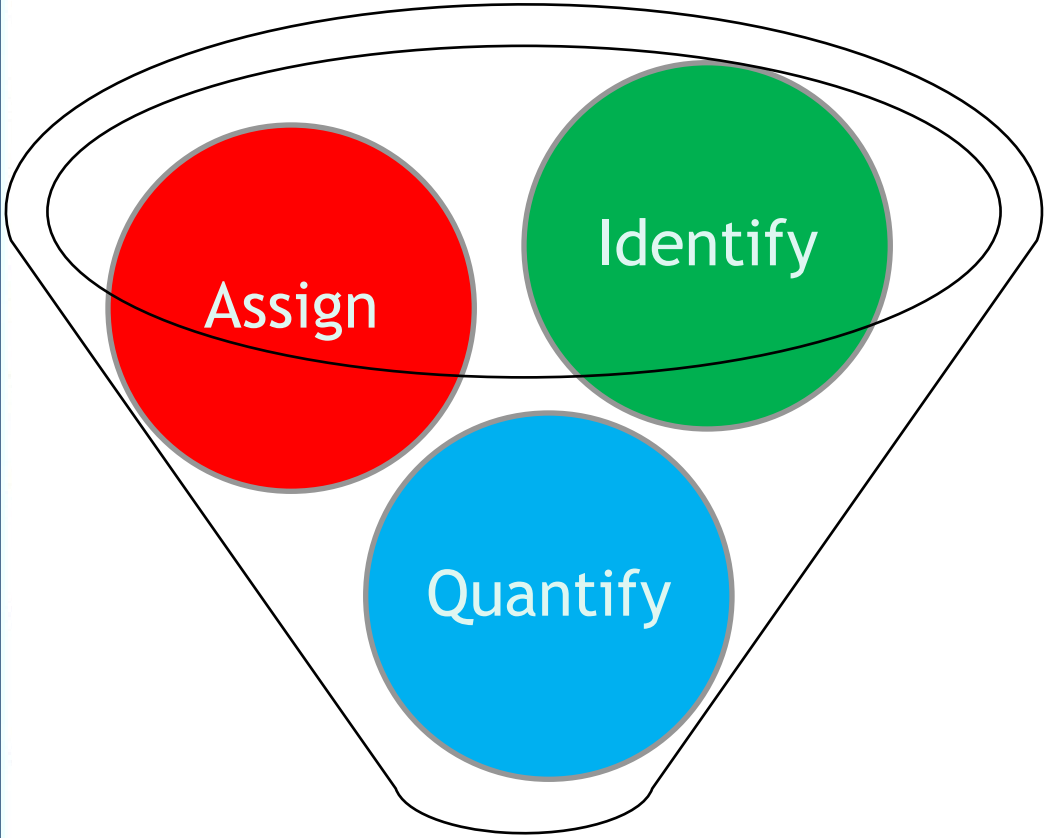
- Reverse engineering
  - Concern may be biased, fake/ unimportant, and inconsistent
- Use an existing spec
  - Concerns more likely relevant, well organized, and consistent

Concern Analysis



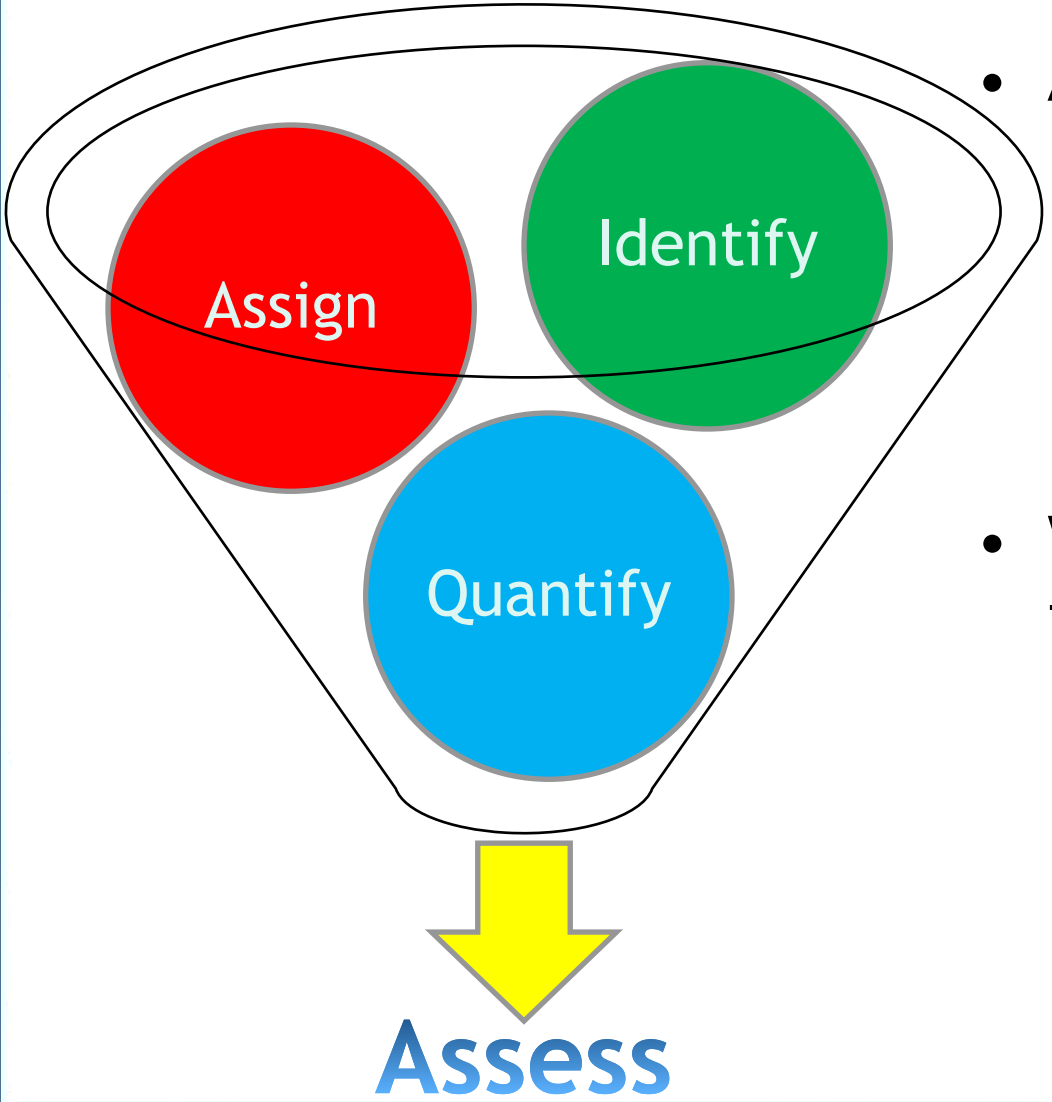
- Which program entities are “relevant”?
- Essentially a reverse engineering exercise
- Hard/impossible to determine accuracy

Concern Analysis



- Need better metrics
- Need empirical validation

Concern Analysis



- Assess impact on
  - Quality (e.g., defects)
  - Understandability
  - Maintenance costs
  - etc.
- Why scattering/tangling impacts quality?
  - Need better theories/models
  - Otherwise, correlations are meaningless

Which entities are relevant?

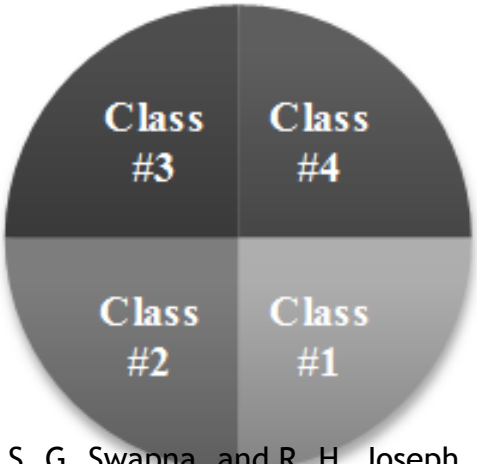
- Entities **dedicated** to one concern
- Entities **shared** by many concerns
  - `Main()` – executed by all concerns
  - `System.String` – reusable/utility class
  - More sharing implies less relevant?
- Our assumption: Relevance based on likely change impact
  - Solves problem for `Main`, but still too vague
  - Cannot consider all possible changes

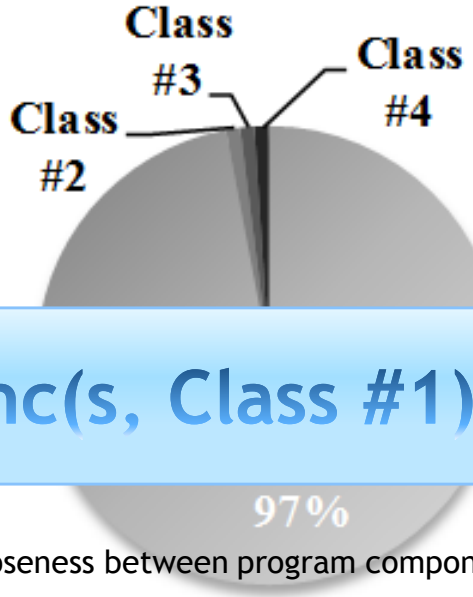
Removal Dependency Assignment

- Our approach: Entities impacted by *eradicating* a concern
  - (Not just disabling the concern)
  - Fairly easy to decide
- Approximates other types of changes
  - Concern modification/addition
  - Empirical evidence needed

Existing Concern Metrics Too Coarse

- Measure *presence* of a concern, not *degree*
- *Diffusion metrics* (Garcia et al.), *spread*





Conc(s, Class #1) = 97%

W. E. Wong, S. G. Swapna, and R. H. Joseph, "Quantifying the closeness between program components and features," *Journal of Systems and Software*, 2000.

Our Metrics: DOS

- *Degree of scattering* – Measures the distribution of a concern's implementation

$$DOS(s) = 1 - \frac{|T|}{|T| - 1} \sum_{t \in T} \left(CONC(s,t) - \frac{1}{|T|} \right)^2$$

- *Average DOS*
  - Overall modularity of concerns
  - Summarizes amount of crosscutting present
- More insightful than traditional product metrics

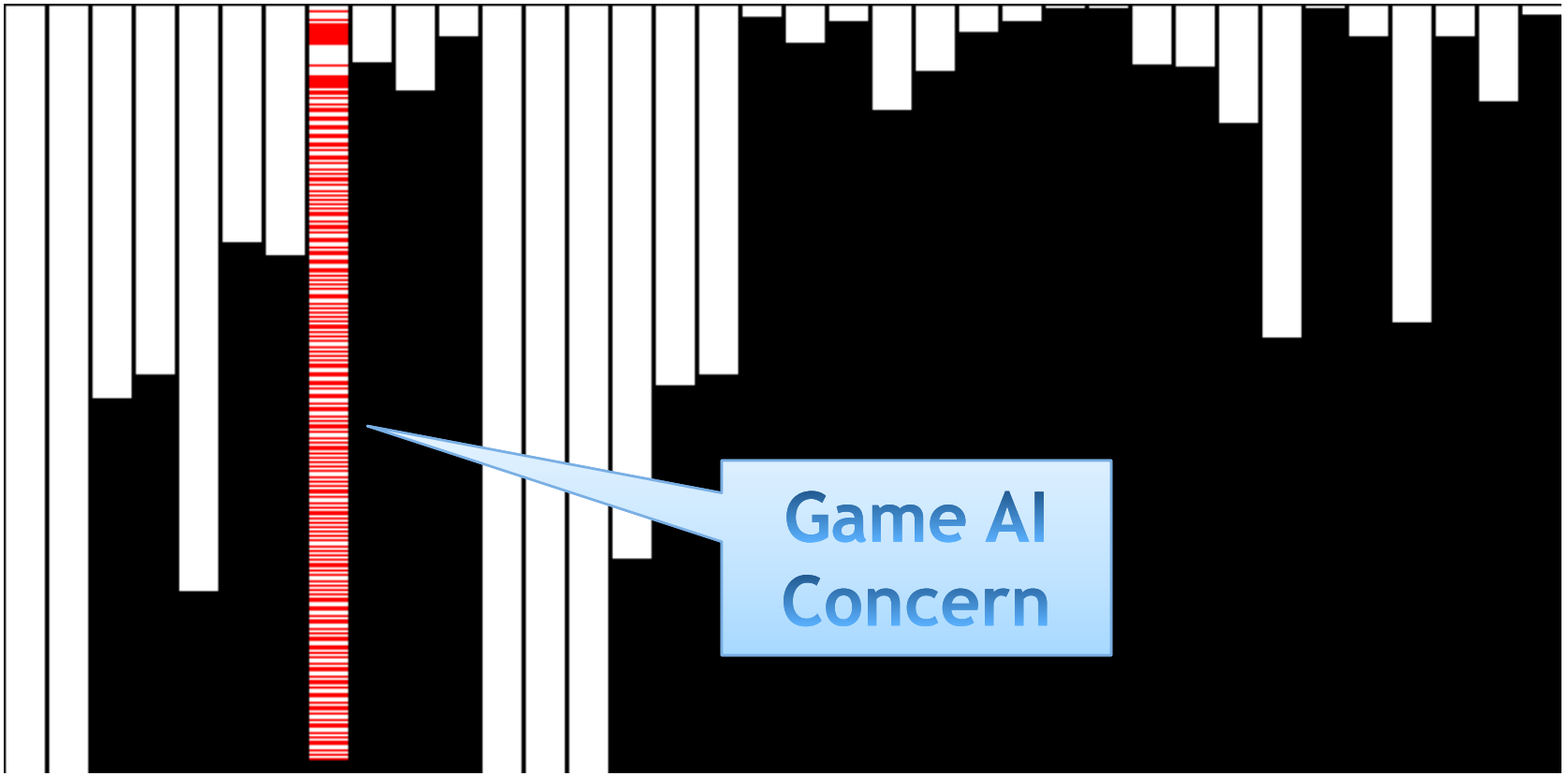
Our Metrics: DOF

- *Degree of focus* – Degree to which component's implementation relates to multiple concerns

$$DOF(t) = \frac{|S|}{|S| - 1} \sum_{s \in S} \left(DEDI(s,t) - \frac{1}{|S|} \right)^2$$

- Reflects amount of tangling
- *Average DOF* – Overall separation of concerns

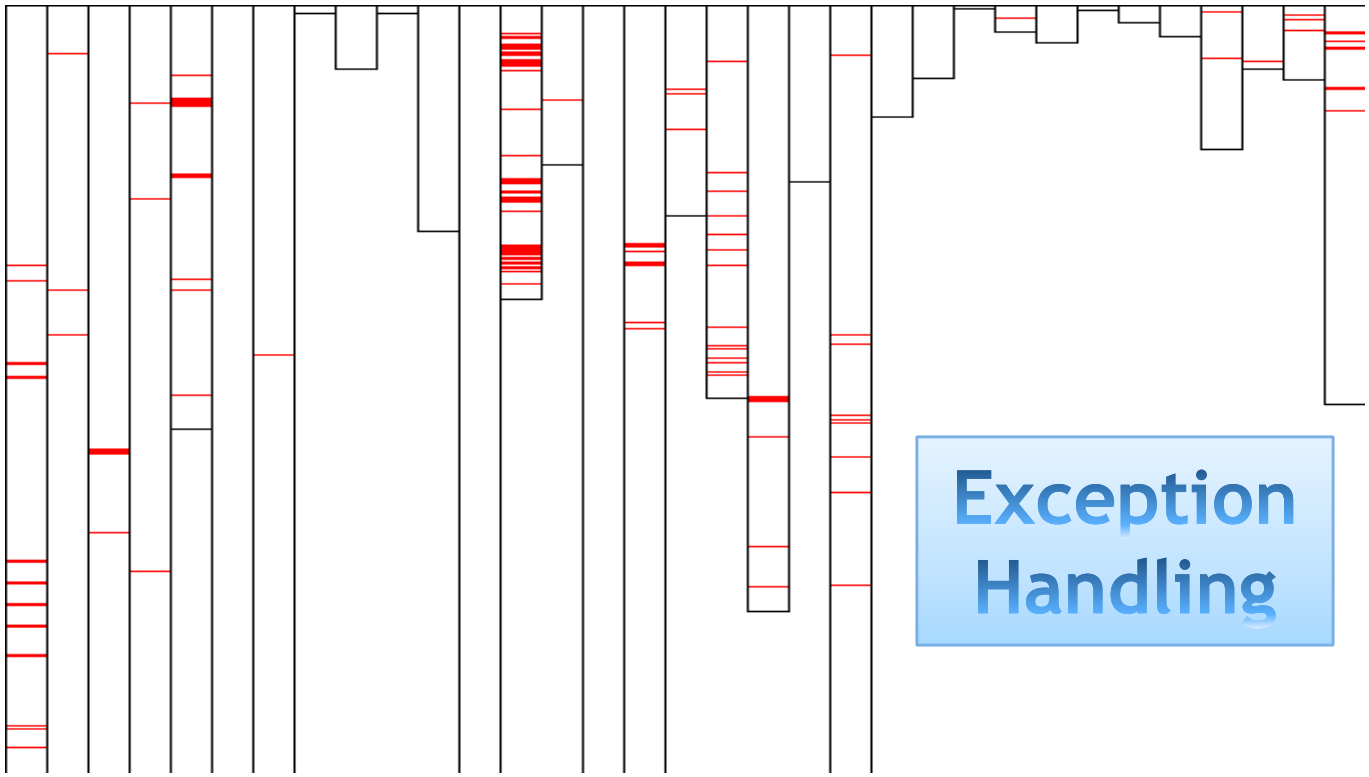
Feasibility Study: Goblin



- Game AI is localized

Goblin: Our Findings

- 95% of Goblin's concerns are scattered
  - Similar findings for two other projects



DOS More Fine-Grained

Concern (Requirement)	*SLOC*	*Concern Diffusion*	*Degree of Scattering*
Graphics API integration	3814	54	0.92
Monocle-display support	2192	10	0.57
Exception/error detection	513	33	0.89
Exception/error handling	455	30	0.80
Collision detection	424	10	0.76
Logging	271	9	0.57
Persistence	190	11	0.83
Clean shutdown	118	13	0.83
Help display	34	1	0.00
Application plug-ins	31	1	0.00

Concluding Remarks

New concern metrics

- Fine-grained measurement of scattering (DOS) and tangling (DOF)
- Recently, found correlation between scattering and defects
- More theoretic and empirical validation needed

Scattering is prevalent

- I.e., a significant problem
- Concerns, bug fixes, changes
- Can we reduce scattering of “real” concerns using OO? AOP?

Thank You!

Contact

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Goblin Dataset

http://www.cs.columbia.edu/~eaddy/goblin