A Case for Static Analyzers in the Cloud

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This talk

Why and how to bring a static analyzer to the cloud?

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Outline:

- Static analyzers today
- Why bringing them to the cloud
- Architecture of a cloud-based static analyzer
- Bonuses, issues

Examplified with our ongoing work on moving Clousot, the .Net Code Contracts static checker, to the cloud.

Code Contracts

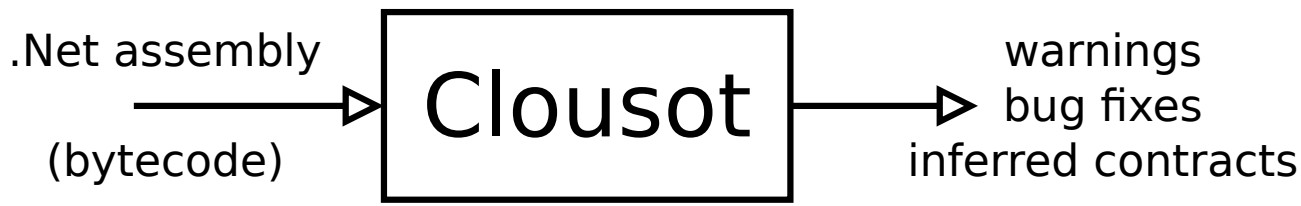
Contracts (preconditions, postconditions, object invariants) for .Net languages.

```
Class PositiveArray {
  int[] arr;

  void ObjectInvariant()
  {
    Contract.Invariant(this.arr != null);
    Contract.Invariant(Contract.ForAll(this.arr, x => x > 0));
  }

  int Max()
  {
    Contract.Requires(this.arr.Length > 0);
    Contract.Ensures(Contract.ForAll(this.arr, x => x <= Contract.Result<int>()));
    Contract.Ensures(Contract.Exists(this.arr, x => x == Contract.Result<int>()));
    ...
  }
}
```

- Contracts can be dynamically checked at runtime
- or statically checked, with Clousot

Clousot today

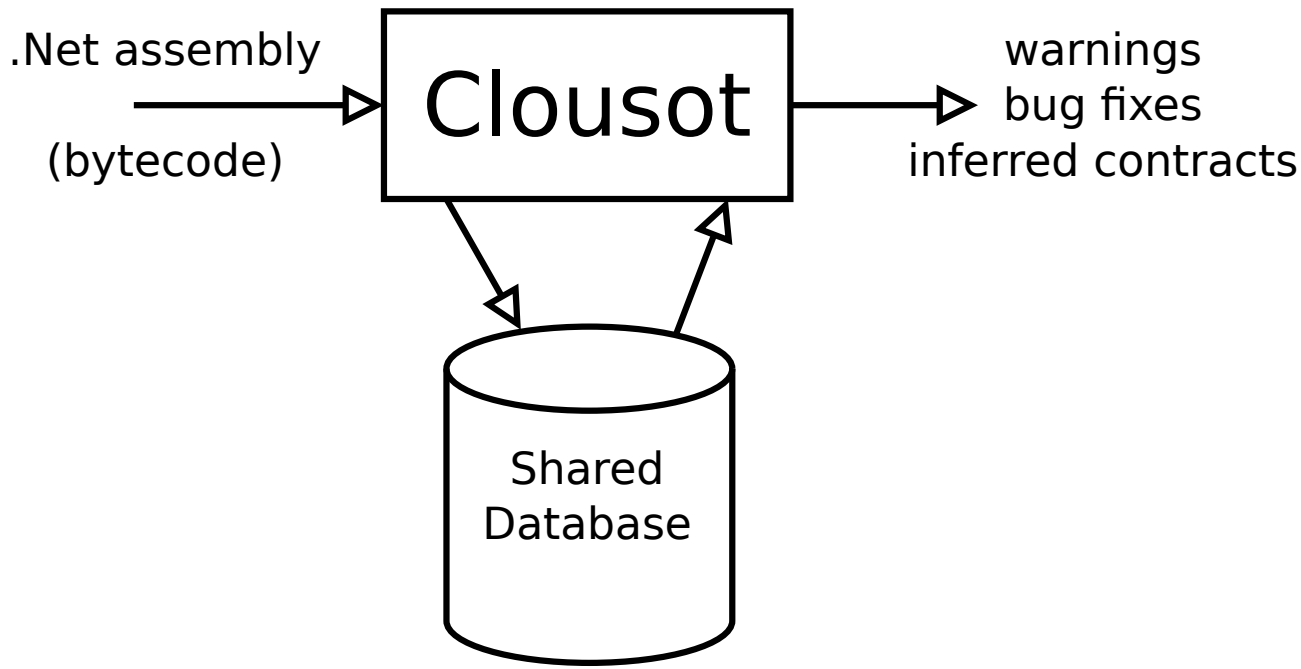
Abstract interpretation-based static checker for Code Contracts.



Clousot runs on a single core of the developer machine.
The bottom-up analysis of methods is sequential.
Analyses start from scratch each time, but analyses are expensive.

How to share results between developers?

Use a common database to share analysis results.



Analyses are still expensive

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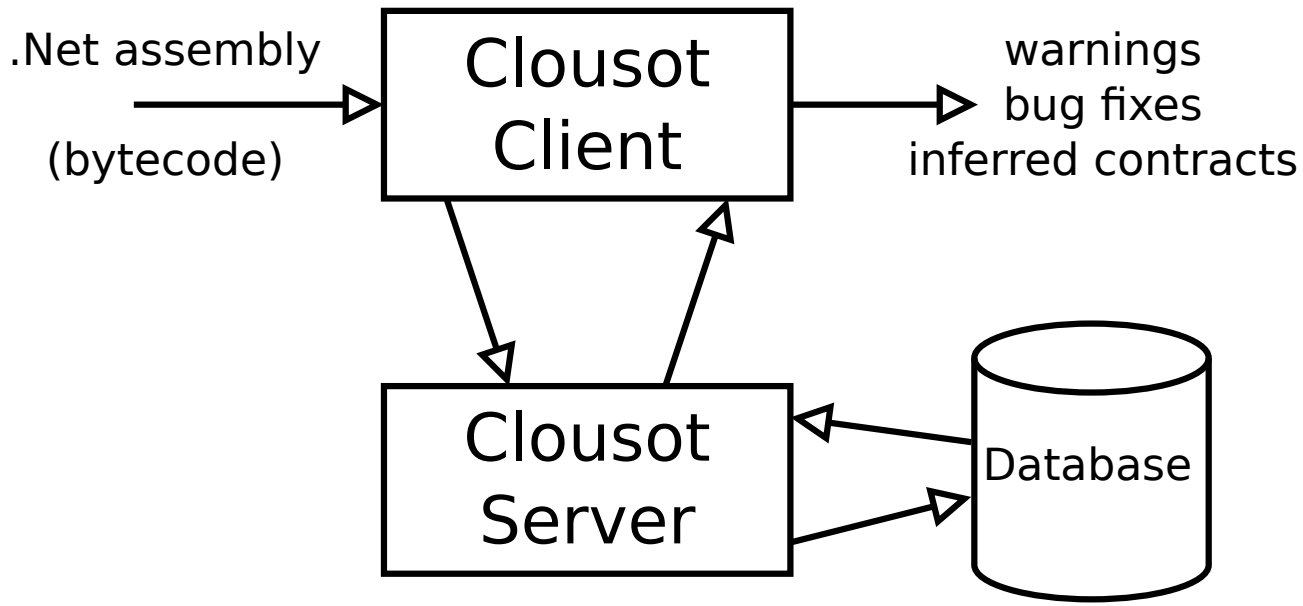
Use more CPUs and more memory, i.e., use a centralized server.



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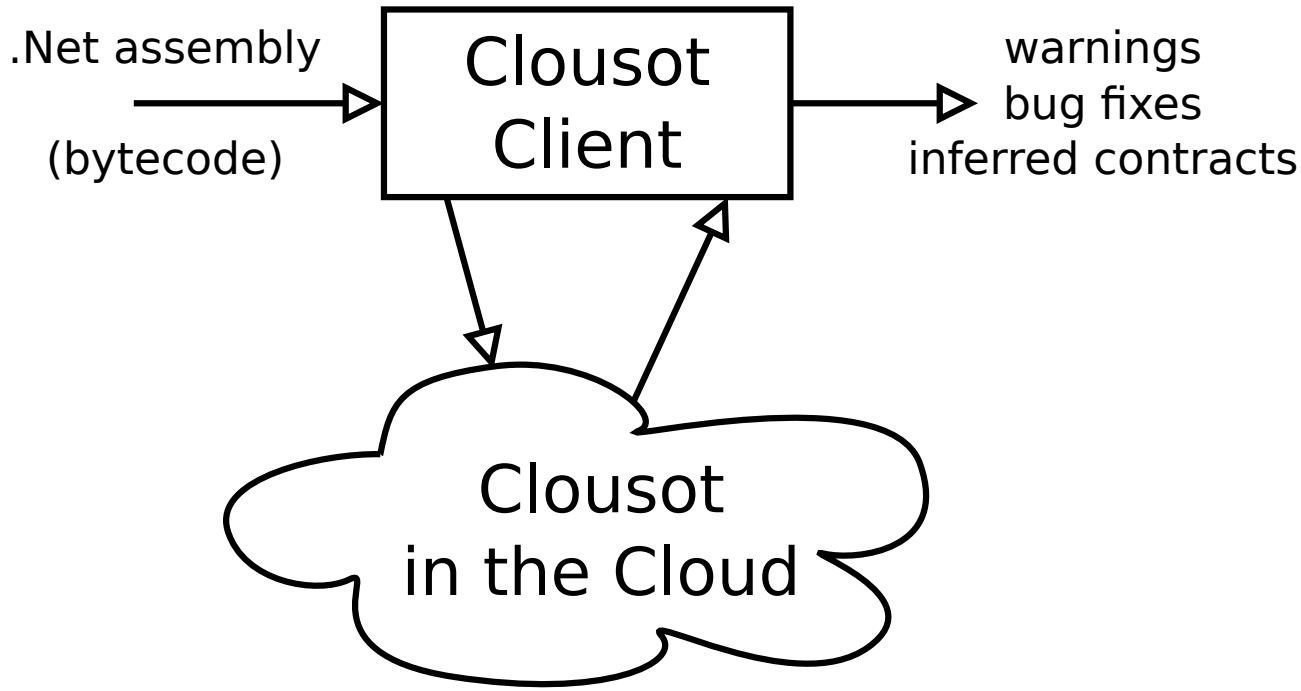
Use the cloud!



Static analyzer as a Cloud service

- Same as a centralized server but on a Cloud infrastructure
- Remote maintenance: one version for everybody
  - Clients do not need to update the tool
  - Faster deployment of bug fixes
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- Results shared by everybody using the tool
- Faster, more precise analyses
- Data collections on the usage of the tool enable:
  - Better understanding of how the tool is used
  - Identify the weaknesses, refine or design new domains
  - Reduction of false alarms
  - Semantics-guided warning suppression
  - Version-based metrics

The client part

- very small (call the service, show the results)
  - used anywhere: smartphone, tablet [TouchDevelop]

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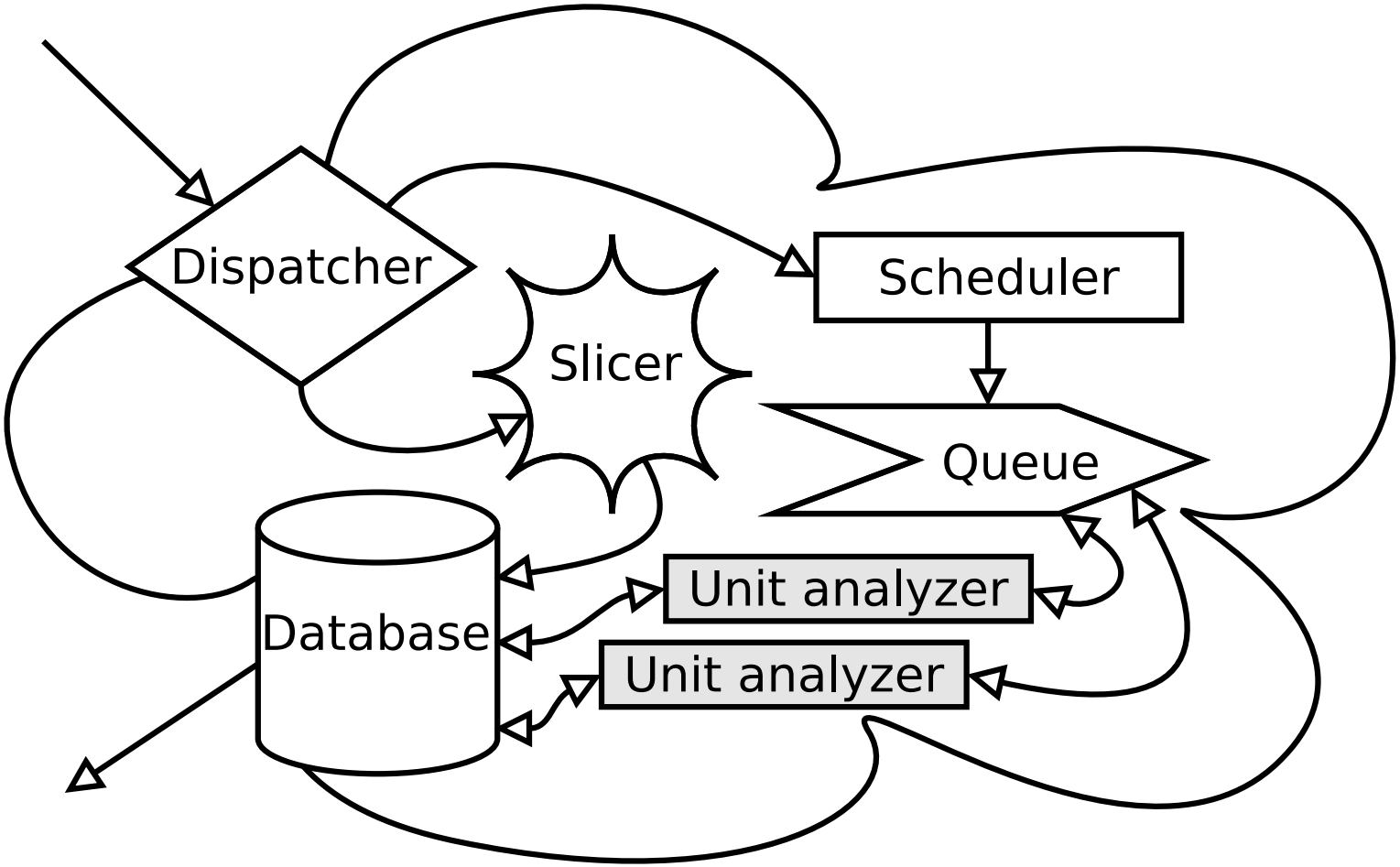
Or a hybrid client:

- analyze "visible" code the developer machine for fast results
- analyze the rest on the Cloud and load results as the developer scrolls

What is in the cloud?



Parallelization

- Past experience: no gain in performance when parallelizing the analysis of a single method. Too much time lost in synchronization, ...
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Slicing

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- Atomic computation: analysis of a method

- Goal: do not ship a big dll file to analyze just a part of it
- Given a .Net assembly and a set of methods M, generate a minimal analyzable unit (MAU) containing:
  - the methods M
  - fake versions of types/methods/properties/fields visible from M
  - their contracts, object invariants, contract classes
  - debugging information (pdb file)

Going further

- Goal: compute a global fixpoint over the analyses of all the methods
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- Method analyses are chaotic and asynchronous
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- Asynchronous iterations [Cousot 77] converge to the greatest fixpoint with no synchronization!
- In the case of monotone operators, only!
- We do not have monotonicity
  - widenings, absence of best abstraction
- Problem can be remediated by forcing monotonicity

Summary: from desktop to the cloud

- make it parallelizable on a single machine (get rid of static variables, etc.)
- make it a service, even if the interface is very simple, i.e., an everlasting process waiting for queries
- optionally, use a centralized database for results and caching
- build the cloud service machinery: service workers, waiting queues, job schedulers
- find an axis of parallelization, with a medium granularity, e.g., some kind of slicing, or independent analyses
- depending on the analysis, global iterations may be needed to compute fixpoints

Issues?

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- Hardly predictable cost

Conclusion

- We (they) are working on Cloudot: a cloud-based version of Clousot, the static analyzer for .Net Code Contracts.
- The cloud enables:
  - fast and precise analyses of large programs thanks to the elasticity of the resources
  - sharing of computation and results
  - easier feedback on the usage of the tool
  - easier deployment of new versions of the tool and contracts for standard libraries

Try Clousot online: `http://rise4fun.com/CodeContracts`

Or download it (90,000+ downloads):
`http://research.microsoft.com/contracts`