Best Practices: Overview & Technically-Related

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Two Important Concerns

- Building the right model
  - Level of depth & breadth: Where to stop in disaggregation?
  - Division between endogenous, exogenous & ignored
- Building the model right
  - For agent-based modeling, this involves consideration of software engineering principles

Building the Model Right: Some Principles of Software Engineering

Technical guidelines

- Eschew speculative complexity
- Use abstraction & encapsulation to simplify reasoning & development
- Name things carefully
- Design & code for transparency & modifiability
- Use configurable logging
- Document & create self-documenting results where possible
- Consider designing for flexibility
- Use defensive programming
- Use type-checking to advantage
  - Subtyping (and sometimes subclassing) to capture commonality
  - For unit checking (where possible)

Process guidelines

- Use peer reviews to review
  - Preliminary design/Code/Tests
- Where possible, perform simple tests to verify functionality
- Preserve successive distinct model versions
- Keep careful track of experiments
- Use tools for version control & documentation & referent.integrity
- Integrate with others' work frequently & in small steps
- Use discovery of bugs to identify process weaknesses

The Challenges of Complexity

- Complexity of software development is a major barrier to effective delivery of value
- Complexity leads to systems that are late, over budget, and of substandard quality
- Complexity has extensive impact in both human & technical spheres

Avoiding Debugging

- Defensive Programming
- Offensive Programming

Offensive Programming: Try to Get Broken Program to Fail Early, Hard

- Asserts: Actually quit the program
- Fill memory allocated with illegal values
- Fill object w/illegal data just before deletion
- Set buffers at end of heap, so that overwrites likely trigger page fault
- Setting default values to be illegal in enums
- We will talk about Assertions & Error Handling later this week

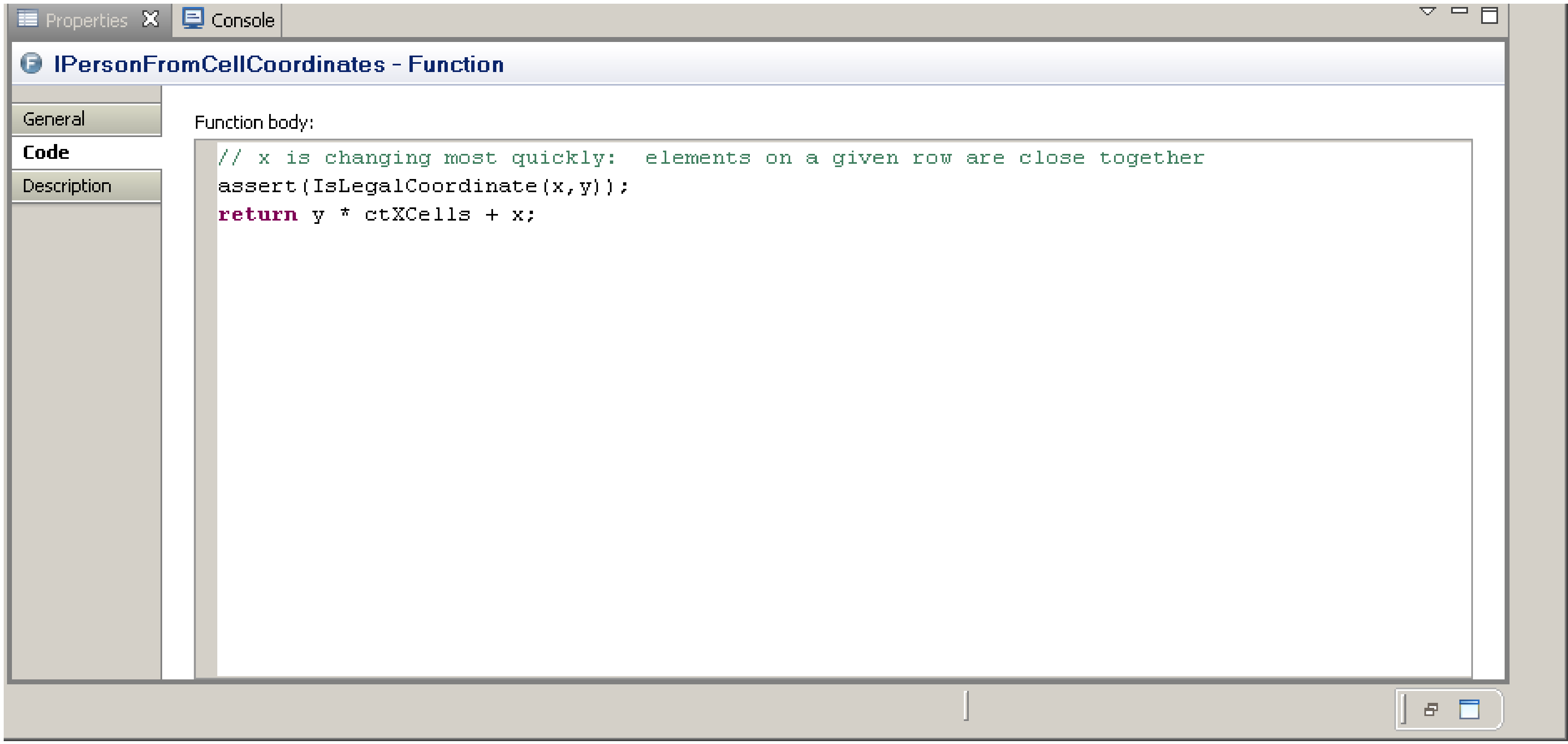
What is an "Assertion"?

- An "Assertion" is a "sanity check" during program execution (model simulation) to confirm that one's assumptions hold true
- This helps identify
  - Mistaken understanding (on our or others' part)
  - Logic errors
  - Inconsistencies in reasoning

Assertion Goal: Fail Early!

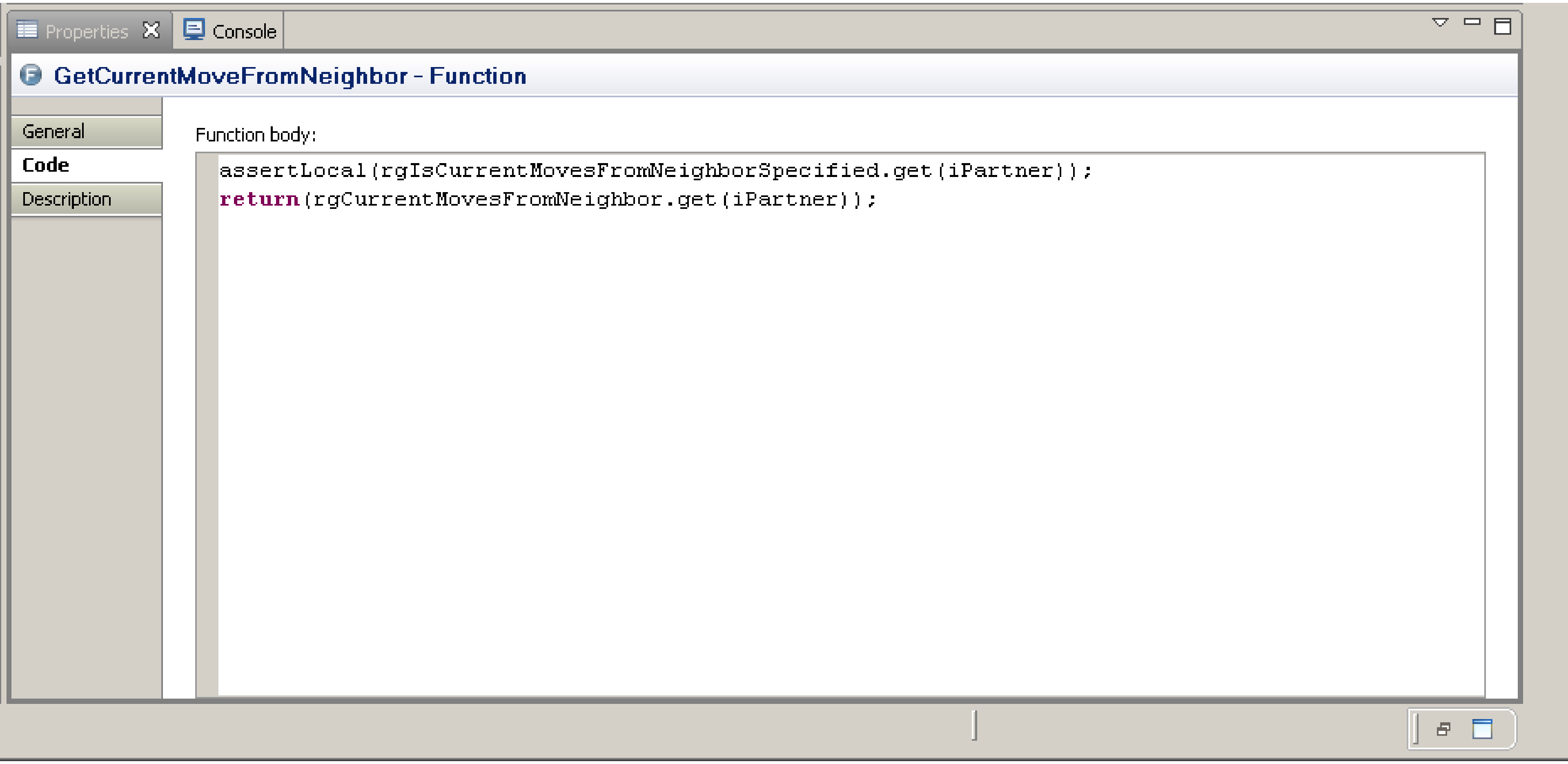
- Alert programmer to misplaced assumptions as early as possible
- Benefits
  - Documents assumptions
  - Reduces likelihood that error will slip through
    - Helps discourage “lazy” handling of only common case
    - Forces developer to deal explicitly with bug before continuing
  - Reduces debugging time
  - Helps improve thoroughness of tests

Assertions Regarding Coordinates



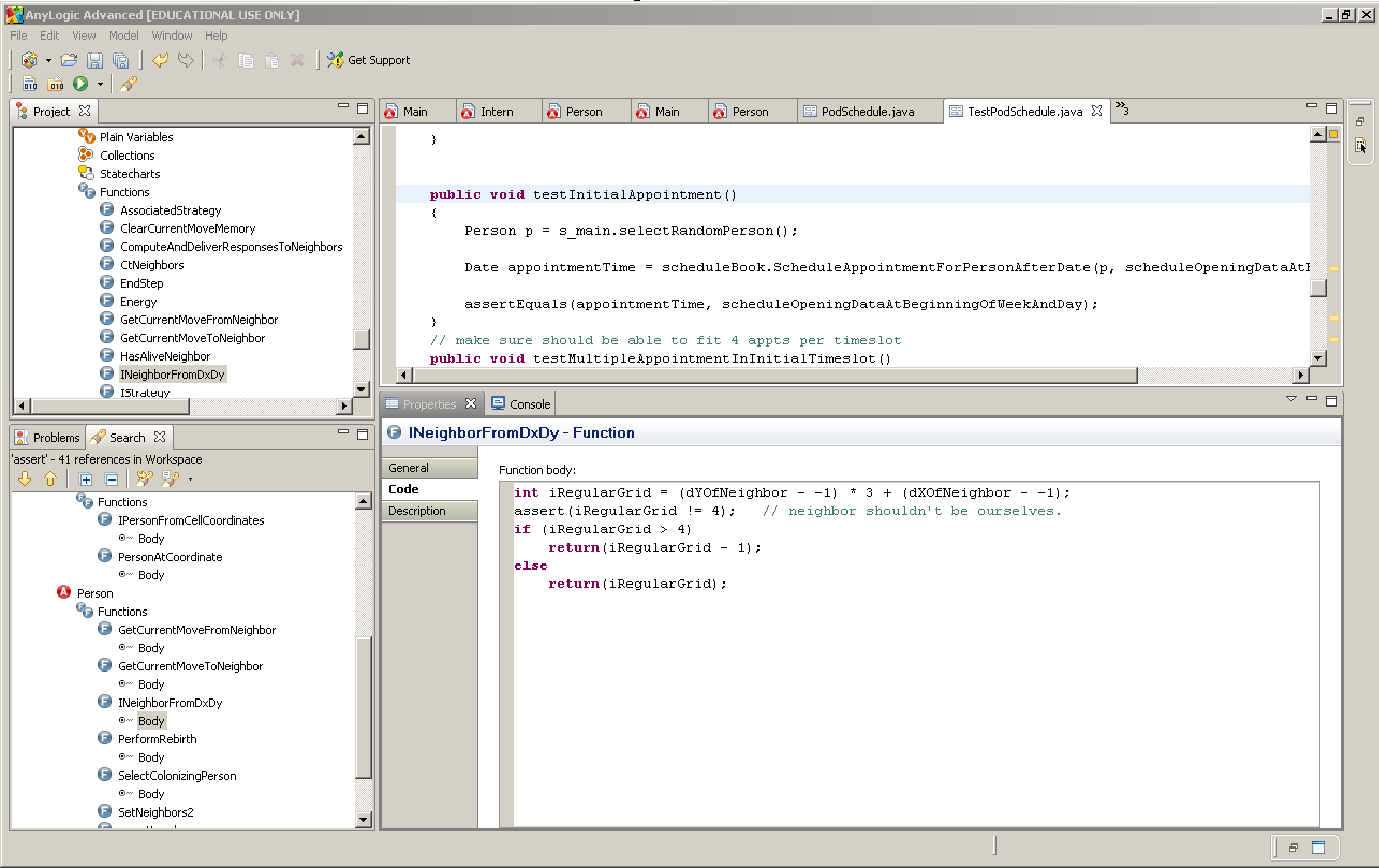
```
// x is changing most quickly:  elements on a given row are close together
assert(IsLegalCoordinate(x,y));
return y * ctXCells + x;
```

Confirming that Something Has Been Computed Before it is Used



```
assertLocal(rgIsCurrentMovesFromNeighborSpecified.get(iPartner));
return(rgCurrentMovesFromNeighbor.get(iPartner));
```

Checking Assumption Regarding Computation



```
    }


    public void testInitialAppointment()
    {
        Person p = s_main.selectRandomPerson();

        Date appointmentTime = scheduleBook.ScheduleAppointmentForPersonAfterDate(p, scheduleOpeningDataAtI

        assertEquals(appointmentTime, scheduleOpeningDataAtBeginningOfWeekAndDay);
    }
    // make sure should be able to fit 4 appts per timeslot
    public void testMultipleAppointmentInInitialTimeslot()
```

```
int iRegularGrid = (dYOfNeighbor - -1) * 3 + (dXOfNeighbor - -1);
assert(iRegularGrid != 4);   // neighbor shouldn't be ourselves.
if (iRegularGrid > 4)
    return(iRegularGrid - 1);
else
    return(iRegularGrid);
```

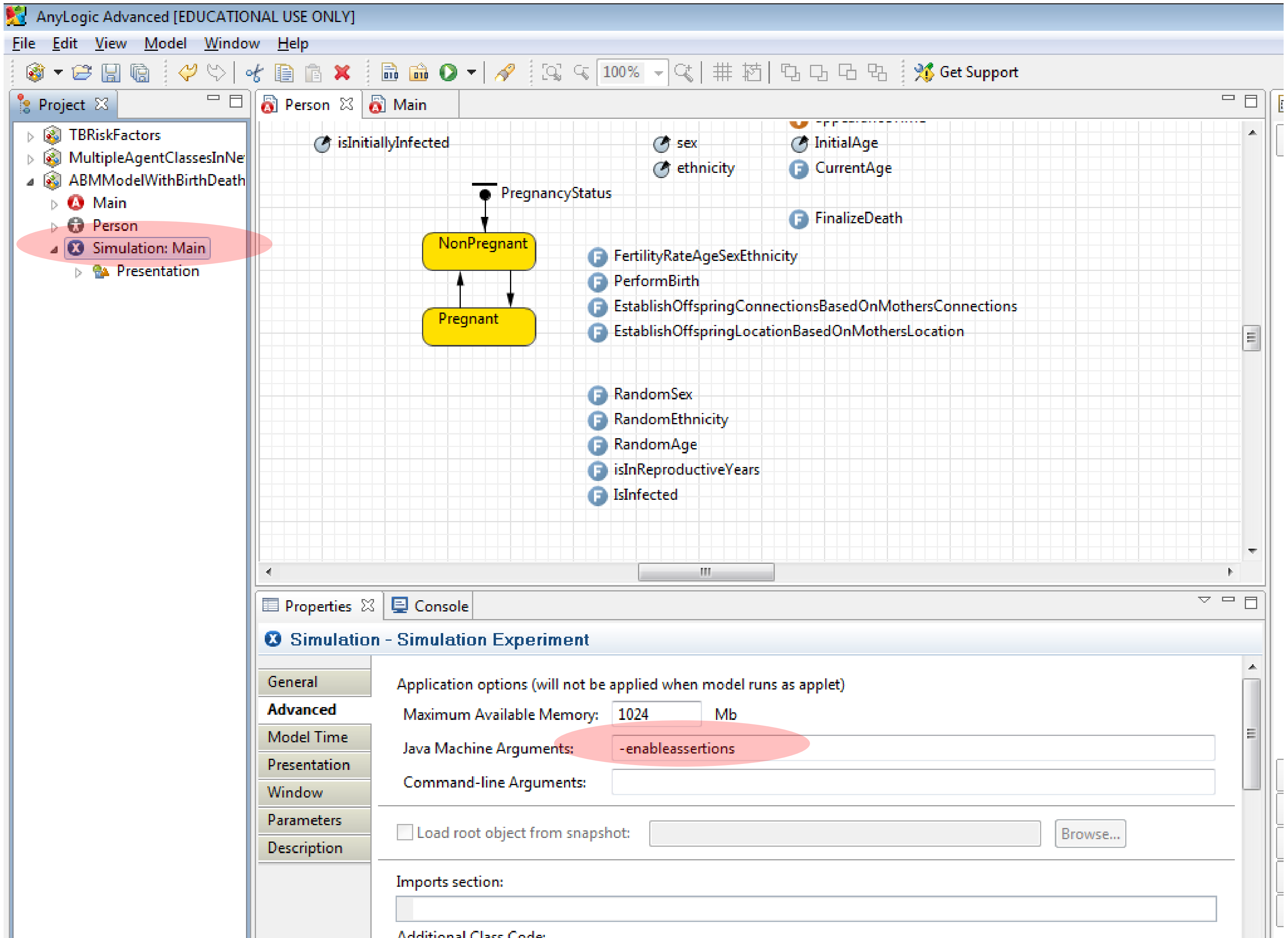
Avoid Side Effects in Assertions

- Because assertions may be completely removed from the program, it is unsafe to rely on side effects occuring in them

```
assert ++i < max;
```

Arnold et al. The Java Programming Language, Fourth Edition. 2006.

Enabling Assertions in AnyLogic



Simulation - Simulation Experiment

Application options (will not be applied when model runs as applet)

Maximum Available Memory: 1024 Mb

Java Machine Arguments: -enableassertions

Command-line Arguments:

Load root object from snapshot:

Imports section:

Additional Class Code:

Arnold et al. The Java Programming Language, Fourth Edition. 2006.

Enabling Assertions in Java

- 2 ways
  - Usual: Via java runtime command line

    `-enableassertions/-ea[`*`descriptor`*`]`

    - e.g.

      ```
      -enableassertions:com.acme.Plotter
      -enableassertions:com.acme...
      ```

    `-disableassertions/-da[`*`descriptor`*`]`

  - Less common: via reflection (ClassLoader)

    ```
    public void setDefaultAssertionStatus(boolean enabled)
    public void setPackageAssertionStatus(String packageName, boolean
       enabled)
    public void setClassAssertionStatus(String className,
       boolean enabled)
    ```

Defensive Programming

- Naming conventions
- Formatting
- Separate
  - Commands (side effects)
  - Queries (pure)
- Avoid manifest constants
- Consolidate condition checks in methods or objects ("specification" pattern)
- Minimize variable lifetime & span between references
- Check return values, value legality
- Always handle all cases (even illegal)
- Always put in { } after if
- Beware empty catch blocks
- Use *finally* blocks
- Don't reuse temporary variables
- Initialize vars, member data as they are declared or in constructor
- Use pseudocode programming process

Other suggestions

- Strive for transparent code
  - Use variable name conventions
  - Consistent formatting
- Strive for higher abstraction level
  - Spot commonality & place into a separate function or class
  - Encapsulate repetitive actions in methods
  - Move whole & partial conditionals to methods
  - Consider putting body of loop in a method
- Create diverse well-named small functions
- Use enumerations

Bad Smells (Many from McConnell, Code Complete 2.0)

- Duplicate code
- Long routine
- Deep/long if/loops
- Inconsistent interface abstraction
- Lots of special cases
- Poor cohesion
- Too many parameters
- Single update yields changes to many places
- Keep on creating ad-hoc data structures/classes
- Global variables
- Primitive types
- Need to update multiple inheritance hierarchies
- Subclasses not really subtypes
- Related items spread among multiple classes
- Method deals more with other classes than its own
- Need to know implementation of other class
- Unclear name
- Setup & takedown code around call

Style & Convention

- Naming Conventions
- Commenting
- Metadata (e.g. Javadocs)
- Indentation
- Module Naming
- Construct placement
- Compiler Pragma & Mechanisms

Naming Conventions

- Naming conventions are a powerful tool
- Benefits
  - Reduce risk of errors
  - Easier understanding of others’ code
  - Easier understanding of code in future
  - Lower risk of name clashes
  - Easier search for desired item (e.g. method/variable/class

Java Naming Conventions

- Distinguish Typographic & Grammatical
- Packages
  - Short lowercase alphabetics (digits rare)
  - Start with organization internet domain name (e.g. ca.usask)
- Classes/interfaces
  - First word of each capitalized (TagHasher)
  - Avoid all but most common abbreviations
  - Generally nouns/noun phrase
  - Interfaces sometimes adjective

Java Naming Conventions 2

- Method & Fields
  - Same as classes but first letter lowercase
  - Const static fields all uppercase, “_” as separ.
  - “Action” methods named with verb
  - “is” for booleans
  - Query: noun/noun phrase or verb w/”get” prefix
  - Converters: “toX”, primitiveValue
- Local variables
  - Same as members but can be short, context-dependent

Booleans

- Base name should give clear sense of condition in question
- Use common convention to indicate boolean
  - “f” prefix (e.g. fOpen)
  - is prefix (e.g. isOpen)
  - “?” suffix (e.g. open? – legal scheme)
- Avoid negation in names (e.g. isNotOpen)

Suggestions

- Use consistent abbreviation conventions
- Provide translation table at top of method to clearly describe purpose of each variable
- Avoid similar names
- Be careful of similar letters
- Avoid overloading predefined names (even if syntactically & semantically allowed)
- Avoid throwaway names for “temporary” vars
- Strive for clarity

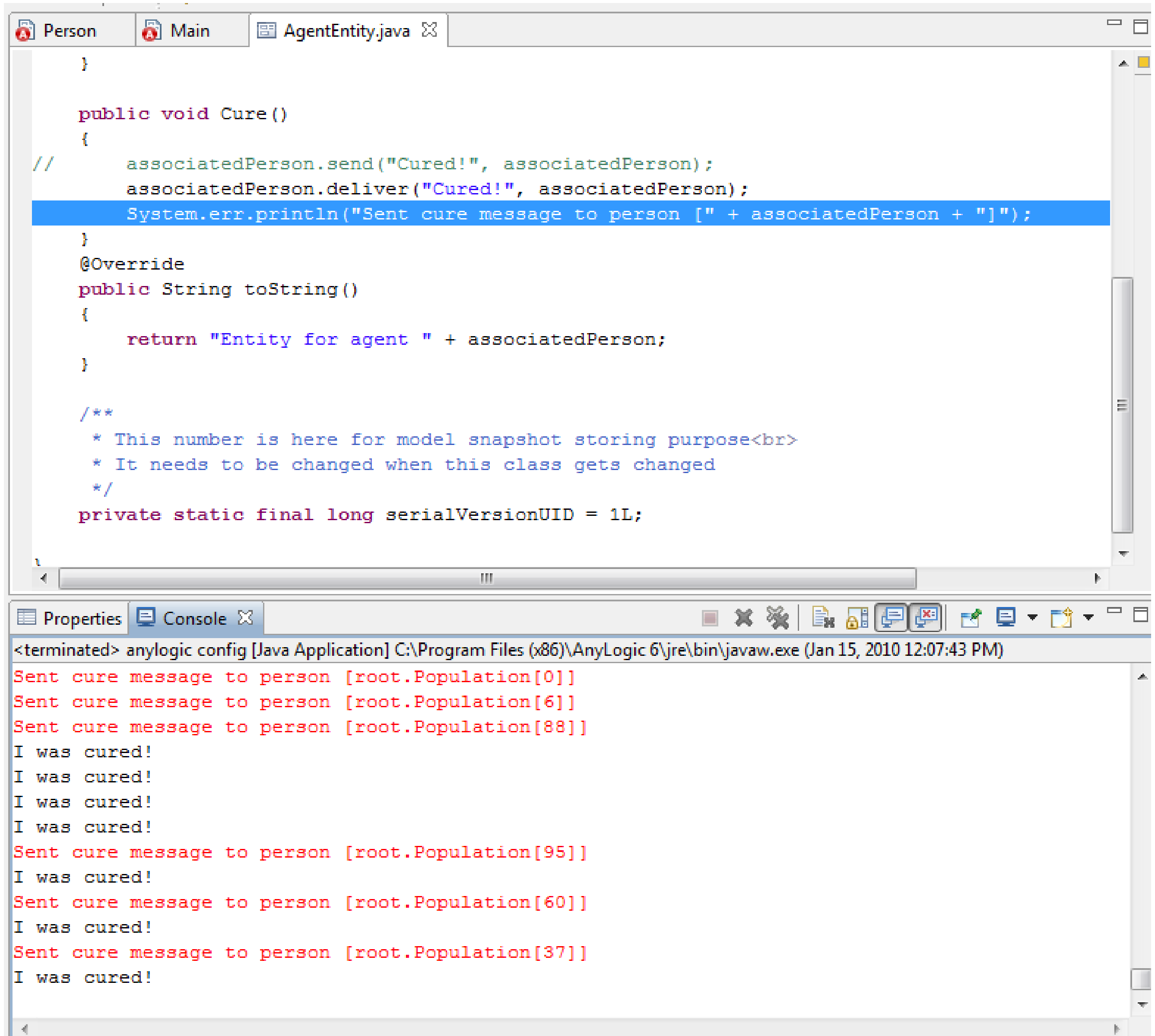
Use Modifiers

- Use “final” (including for parameters in Java) to prevent side-effects
  - This is exposed through the Anylogic interface
  - Examples
    - Prevent modification to *this* in method
    - Prevent assignment to parameter
- *Declaring variables as static* can prevent needless memory use

Output to the Console

- System.err.println(String)
  - System.err.println("Sent cure message to person [" + associatedPerson + "]");
- traceln(String)

Use in AnyLogic



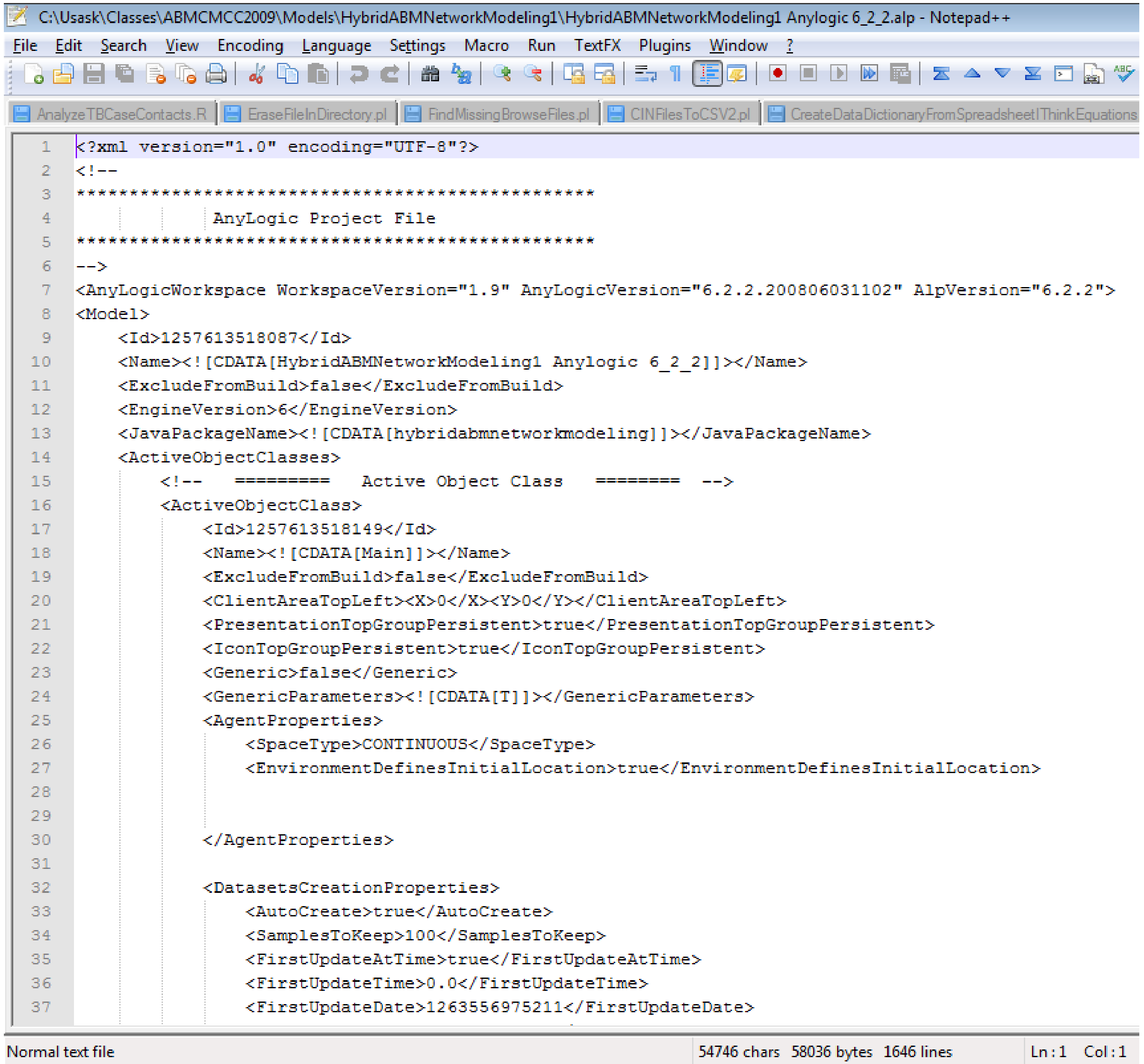
```java
    }

    public void Cure()
    {
//        associatedPerson.send("Cured!", associatedPerson);
        associatedPerson.deliver("Cured!", associatedPerson);
        System.err.println("Sent cure message to person [" + associatedPerson + "]");
    }
    @Override
    public String toString()
    {
        return "Entity for agent " + associatedPerson;
    }

    /**
     * This number is here for model snapshot storing purpose<br>
     * It needs to be changed when this class gets changed
     */
    private static final long serialVersionUID = 1L;
```

```
<terminated> anylogic config [Java Application] C:\Program Files (x86)\AnyLogic 6\jre\bin\javaw.exe (Jan 15, 2010 12:07:43 PM)
Sent cure message to person [root.Population[0]]
Sent cure message to person [root.Population[6]]
Sent cure message to person [root.Population[88]]
I was cured!
I was cured!
I was cured!
I was cured!
Sent cure message to person [root.Population[95]]
I was cured!
Sent cure message to person [root.Population[60]]
I was cured!
Sent cure message to person [root.Population[37]]
I was cured!
```

Internals of AnyLogic files: XML


C:\Usask\Classes\ABMCMCC2009\Models\HybridABMNetworkModeling1\HybridABMNetworkModeling1 Anylogic 6_2_2.alp - Notepad++
File Edit Search View Encoding Language Settings Macro Run TextFX Plugins Window ?
AnalyzeTBCaseContacts.R
EraseFileInDirectory.pl
FindMissingBrowseFiles.pl
CINFilesToCSV2.pl
CreateDataDictionaryFromSpreadsheetIThinkEquations
Normal text file
54746 chars 58036 bytes 1646 lines
Ln : 1 Col : 1

```xml
<?xml version="1.0" encoding="UTF-8"?>
<!--
*************************************************
            AnyLogic Project File
*************************************************
-->
<AnyLogicWorkspace WorkspaceVersion="1.9" AnyLogicVersion="6.2.2.200806031102" AlpVersion="6.2.2">
<Model>
    <Id>1257613518087</Id>
    <Name><![CDATA[HybridABMNetworkModeling1 Anylogic 6_2_2]]></Name>
    <ExcludeFromBuild>false</ExcludeFromBuild>
    <EngineVersion>6</EngineVersion>
    <JavaPackageName><![CDATA[hybridabmnetworkmodeling]]></JavaPackageName>
    <ActiveObjectClasses>
        <!--   =========   Active Object Class   ========   -->
        <ActiveObjectClass>
            <Id>1257613518149</Id>
            <Name><![CDATA[Main]]></Name>
            <ExcludeFromBuild>false</ExcludeFromBuild>
            <ClientAreaTopLeft><X>0</X><Y>0</Y></ClientAreaTopLeft>
            <PresentationTopGroupPersistent>true</PresentationTopGroupPersistent>
            <IconTopGroupPersistent>true</IconTopGroupPersistent>
            <Generic>false</Generic>
            <GenericParameters><![CDATA[T]]></GenericParameters>
            <AgentProperties>
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                <EnvironmentDefinesInitialLocation>true</EnvironmentDefinesInitialLocation>


            </AgentProperties>

            <DatasetsCreationProperties>
                <AutoCreate>true</AutoCreate>
                <SamplesToKeep>100</SamplesToKeep>
                <FirstUpdateAtTime>true</FirstUpdateAtTime>
                <FirstUpdateTime>0.0</FirstUpdateTime>
                <FirstUpdateDate>1263556975211</FirstUpdateDate>
```