Object-oriented programming: challenges for the next fifty years

Prof. Andrew P. Black
Portland State University, Portland, Oregon, USA.
UiO’s 200th birthday is celebrated with a big concert, and the entire university comes together for a unique shared experience at Blindern!

Bigbang gives us an exclusive concert for our birthday! They invite a number of musical friends to play their own and each others' songs.

Food and drink on sale at Frederikkeplassen

19:00 Two options:

1. Birthday Party: Ole-Johan Dahl's House (IFI2)
UiO's newest venue Ole-Johan Dahl's house is inaugurated with a birthday party on three floors! There will be concerts, comedy, long tables and Oslo's longest bar.

2. Classic club: Georg Sverdrup’s House
The foyer of Georg Sverdrup's house is transformed into classic club! A dream team of classical performers and UiO's own choirs and orchestra make for a festive evening. Artists: Arve Tellefsen, Elizabeth Norberg-Schulz and more

22.00 Afterparty, Chateau Neuf
The party rounds up with a packed club night at Betong and the rest of Chateau Neuf. Here you can dance the night away or keep the conversations going late into the night.
Just suppose ...
Just suppose ...

- You have been “drafted”
Just suppose ...

• You have been “drafted”

• Your assignment:
Just suppose ...

• You have been “drafted”

• Your assignment:

  design your country’s first nuclear reactor
Just suppose ...

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• What would you do?
Just suppose ...

• You have been “drafted”

• Your assignment:
  design your country’s first nuclear reactor

• What would you do?

• What did Kristen Nygaard do?
A Little History

1948: Nygaard conscripted into the Norwegian Defense Research Establishment

1949–1950: Resonance absorption calculations related to the construction of Norway’s first nuclear reactor. Introduced “Monte Carlo” simulation methods

1950-1952: Head of the “computing office”

1960: Moved to the Norwegian Computing Centre. “Many of the civilian tasks turned out to present the same kind of methodological problems: the necessity of using simulation, the need of concepts and a language for system description, lack of tools for generating simulation programs.” [Nygaard1981]

1961: Started designing a simulation language

Nygaard’s Famous Letter: 5th January 1962

“The status of the Simulation Language (Monte Carlo Compiler) is that I have rather clear ideas on how to describe queueing systems, and have developed concepts which I feel allow a reasonably easy description of large classes of situations. I believe that these results have some interest even isolated from the compiler, since the presently used ways of describing such systems are not very satisfactory. … The work on the compiler could not start before the language was fairly well developed, but this stage seems now to have been reached. The expert programmer who is interested in this part of the job will meet me tomorrow. He has been rather optimistic during our previous meetings.” [Nygaard1981]
Ole-Johan Dahl

The “Expert Programmer”
Ole-Johan Dahl

1931–2002

Norway’s foremost computer scientist

With Kristen Nygaard, produced initial ideas for Object-oriented programming
Ole-Johan Dahl

Honours:

Royal Norwegian Order of St. Olav (2000)

ACM Turing Award (2001)

ACM Turing Award Citation

“... to Ole-Johan Dahl and Kristen Nygaard of Norway for their role in the invention of object-oriented programming, the most widely used programming model today.

... the core concepts embodied in their object-oriented methods were designed for both system description and programming ... ”
Today’s Talk:

- What are those “core concepts”?  
- How they have evolved over the last 50 years.  
- How they might adapt to the future.
General Program for the Centennial Celebration Massachusetts Institute of Technology, Cambridge April 7, 8, and 9, 1961
Saturday
April 8


Panel, 10:00 a.m., Kresge Auditorium. The Future of the Arts in a World of Science. Lukas Foss, Howard Mumford Jones, Louis A. Kahn, and Richard Lippold.

Panel, 10:00 a.m., Compton Lecture Hall. The Future in the Physical Sciences. Sir John D. Cockcroft, Richard P. Feynman, Rudolf Peierls, and Chen Ning Yang.


Panel, 2:30 p.m., Compton Lecture Hall. The Future in the Life Sciences. George W. Beadle, Peter B. Medawar, Hermann J. Muller, and Dr. Jonas E. Salk.
Physics in the Future:
Will It Be Monotonous?

BY ROBERT TOTH

WE LIVE in a heroic age in the physical sciences, one that will be looked at with great jealousy in times to come. America could be discovered only once; so, too, the fundamental laws of physics can be discovered only once. The situation now is pregnant.

Thus Professor Richard P. Feynman, 39, theoretical physicist at California Institute of Technology, sees the future of the physical sciences. The other three distinguished panelists who discussed the issue with him on an M.LT. Centennial panel April 8 shared his view that they are in the midst of a brilliant dawn of discovery. Professor Francis E. Low of M.LT.’s Department of Physics introduced the speakers.

By assessing the past and extrapolating into the future, they addressed themselves to the question: How long will the dawn last? History does not repeat itself—or perhaps the only lesson learned from history is that no lesson is learned from history—but a look at the 60 elapsed years of this century shows three profound discoveries: special and general relativity theories and quantum mechanics.

Will this pace of fundamental discovery continue unabated? Will it increase? Or will it peter out into the filling of gaps left as the great giant of discovery strides forward? Or will the game end abruptly in one burst of all-illuminating light?

“It is possible,” Professor Feynman said, “that there is a final solution,” a final unifying law that will explain all of the diverse physical effects seen in the nucleus and the cosmos.

The giant of science is advancing on two feet, one experimental, the other theoretical, he said. The experimental leg at this point in time is far ahead. It has flushed out the profusion of elementary sub-nuclear particles which theorists are at a loss to explain. This giant is now running through a long and darkened building, Dr. Feynman’s analogy continued. It may seem to have no ending, only a series of doors each of which must be opened in turn. But it is unwarranted pessimism to say now that there is no single, final answer. Only if the fundamental laws of physics change with absolute time—and he suggested that this was also a possibility—would there be no final answer.

Professor Chen Ning Yang of the Institute for Advanced Study in Princeton disagreed. He saw an infinite number of doors in the future. “The depth of natural phenomena is limitless,” this young Nobel Prize winner said. When all other questions are answered, man will still be faced with the ultimate one: “How do we understand that we understand?” Even before that, after man has formulated laws regarding how things work, he must cope with such problems as “what is a magnetic field?”

“But even that can’t go on forever,” said Professor R. E. Peierls, a mathematical physicist from the University of Birmingham in England. Magnetic fields today are explained in terms of hydrodynamics dependent on the actions of molecules. Below molecules are atoms and nuclei, whose actions depend on magnetic fields to some extent. So we come full circle, he said. Once magnetic fields are explained fully, the circle will be forever broken.

While the panelists could not agree—perhaps on philosophical grounds—on the probable end of the road of discovery, they thought they could see relatively clearly what the next few strides along that road might be.

“The rapid widening of knowledge will continue,” Dr. Yang predicted. In nuclear physics, he expects

(Concluded on page 66)
“I do not think that you can read history without wondering what is the future of your own field, in a wider sense. I do not think that you can predict the future of physics alone [without] the context of the political and social world in which it lies. ...
Feynman’s speech:

“I do not think that you can read history without wondering what is the future of your own field, in a wider sense. I do not think that you can predict the future of physics alone [without] the context of the political and social world in which it lies. ...

The other speakers want to be safe in their predictions, so they predict for 10, perhaps 25 years ahead. They are not so safe because you will catch up with them and see that they were wrong. So, I’m going to be really safe by predicting 1000 years ahead.” [Feynman1962]
Political and Social Context
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1. Simula was designed as process description language as well as a programming language.
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*When SIMULA I was put to practical work it turned out that to a large extent it was used as a system description language. A common attitude among its simulation users seemed to be: sometimes actual simulation runs on the computer provided useful information. The writing of the SIMULA program was almost always useful, since ... it resulted in a better understanding of the system.* [Nygaard1981]
Political and Social Context
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2. Nygaard had been using simulations to design Nuclear reactors.
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*He did not want to be responsible for the first nuclear accident on the continent of Europe.*

[Ungar2011]
Core Ideas of SIMULA

According to Nygaard:

1. Modelling
   The actions and interactions of the objects created by the program model the actions and interactions of the real-world objects that they are designed to simulate.

2. Security
   The behavior of a program can be understood and explained entirely in terms of the semantics of the programming language in which it is written.
Core Ideas of SIMULA

According to Dahl:
[Dahl1981]

1. Record structures
2. Procedural data abstraction
3. Processes
4. Prefixing (inheritance)
5. Modules

Core Ideas of SIMULA

According to Dahl: all came from the Algol 60 block [Dahl1981]

1. Record structures (block with variable declarations but no statements)
2. Procedural data abstraction (block with variable and procedure declarations)
3. Processes (detached blocks)
4. Prefixing (inheritance) (prefix blocks)
5. Modules (nested blocks)
The SIMULA **class** construct

All these ideas were realized as special cases of a single general construct: the **class**.

But object-oriented programming is *not* class-oriented programming!

Dahl wrote: “I know that SIMULA has been criticized for perhaps having put too many things into that single basket of class. Maybe that is correct; I’m not sure myself. But it was certainly great fun during the development of the language to see how the block concept could be remodeled in all these ways”  

[Dahl1981]
The Origin of the Core Ideas
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Dahl was inspired by visualizing the *runtime representation* of an Algol 60 program.
The Origin of the Core Ideas

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Frame 5

The Origin of the Core Ideas

Dahl was inspired by visualizing the runtime representation of an Algol 60 program.

Objects were already in existence inside every executing Algol program — they just needed to be freed from the "stack discipline"
Algol 60’s “Stack discipline”
Algol 60’s “Stack discipline”

“In ALGOL 60, the rules of the language have been carefully designed to ensure that the lifetimes of block instances are nested, in the sense that those instances that are latest activated are the first to go out of existence. It is this feature that permits an ALGOL 60 implementation to take advantage of a stack as a method of dynamic storage allocation and relinquishment. But it has the disadvantage that a program which creates a new block instance can never interact with it as an object which exists and has attributes, since it has disappeared by the time the calling program regains control. Thus the calling program can observe only the results of the actions of the procedures it calls. Consequently, the operational aspects of a block are overemphasised; and algorithms (for example, matrix multiplication) are the only concepts that can be modelled.” [Dahl1972]
Two simple changes:

“In SIMULA 67, a block instance is permitted to outlive its calling statement, and to remain in existence for as long as the program needs to refer to it.” [Dahl1972]

A way of referring to “it”: object references as data
Simula Class Prefixing

prefixing

CLASS A; ...
REF (A) X;
.....
X: -NEW A

A CLASS B; ...
REF (B) Y;
.....
Y: -NEW B

Frame 8
[Nygaard1981a]
Modern Class Prefixing

![Class Diagram]

- **BankAccount**
  - owner : String
  - balance : Dollars
  - deposit ( amount : Dollars )
  - withdrawal ( amount : Dollars )

- **CheckingAccount**
  - insufficientFundsFee : Dollars
  - processCheck ( checkToProcess : Check )
  - withdrawal ( amount : Dollars )

- **SavingsAccount**
  - annualInterestRate : Percentage
  - depositMonthlyInterest ( )
  - withdrawal ( amount : Dollars )

Diagrams from IBM developerworks
Modern Class Inheritance

```
BankAccount
owner : String
balance : Dollars

deposit ( amount : Dollars )
withdrawal ( amount : Dollars )

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diagrams from IBM developerworks
The Importance of Inheritance

Since 1989, thanks to William Cook, we have known that inheritance can be translated into fixpoints of generators of self-referential functions. [Cook1989a]

So much for the theory.

Are functions parameterized by functions as good as inheritance?

In theory: yes.
The Importance of Inheritance

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Are functions parameterized by functions as good as inheritance?

In theory: yes.

In practice: no.

Parameterized functions instead of Inheritance?
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When you parameterize a function, you have to *plan ahead* and make parameters out of every part that could possibly change.

functional programmers call this “abstraction”
Parameterized functions instead of Inheritance?

When you parameterize a function, you have to *plan ahead* and make parameters out of every part that could possibly change.

functional programmers call this “abstraction”

Two problems:

1. Life is uncertain
2. Most people think better about the concrete than the abstract
The value of Inheritance

When you inherit from a class or an object, you still have to *plan ahead* and make methods out of every part that could possibly change.

o-o programmers call this “writing short methods”

Two benefits:

1. You don’t have to get it right
2. The short methods are *concretions*, not abstractions
Inheritance Example

Rectangle extends Object

```
def bounds       — my bounding box
def inset        — space around me
```

```
Rectangle » drawOn(aCanvas)
   self drawFrameOn(aCanvas)
   self fillRegionOf(aCanvas)
```

```
Rectangle » drawFrameOn(aCanvas)
aCanvas strokeRectangle(bounds+inset)
```

```
Rectangle » fillRegionOf(aCanvas)
aCanvas fillRectangle(bounds)
```
Inheritance Example

Circle extends Rectangle

def radius — my radius

Circle » fillRegionOf(aCanvas)

aCanvas

fillCircleWithCenterAndRadius
(bounds center, radius)
People Learn from Examples

Inheritance provides a concrete example, and then generalizes from it.

For example:

1. Solve the problem for $n = 4$

2. Then make the changes necessary for 4 to approach infinity
Object-oriented Frameworks
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In my view, one of the most significant contributions of SIMULA 67:
Object-oriented Frameworks

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Allowing SIMULA to be expressed as a framework within SIMULA 67
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SIMULA begin ... end
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SIMULA begin ... end

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class SIMSET, and
SIMSET class SIMULATION
What is an O-O Framework?

Generalization of a subroutine library:
client calls subroutines in a library, which always return to the caller

in a Framework:
client method calls methods in the framework
framework methods call methods in the client

e.g., a simulation framework might tell objects representing reactor control rods or industrial saws to perform

perform methods might ask the framework about environmental conditions
Smalltalk

Smalltalk-72 was clearly inspired by Simula

- It took:
  - Classes, Objects, Inheritance, Object References

- It refined and explored:
  - Objects as *little computers*: “a recursion on the notion of computer itself” [Kay1993]
  - Objects combining data and the operations on that data

- It dropped:
  - Objects as processes, classes as packages

Warning:

Unlike Simula and Smalltalk, this is a descriptive work, not a prescriptive one.
The essential concepts

- An object embodies an abstraction characterized by services.
- Clients request services from objects.
  - Clients issue requests.
  - Objects are encapsulated.
  - Requests identify operations.
  - Requests can identify objects.
- New objects can be created.
- Operations can be generic.
- Objects can be classified in terms of their services (interface hierarchy).
- Objects can share implementations.
  - Objects can share a common implementation (multiple instances).
  - Objects can share partial implementations (implementation inheritance or delegation).
# US & Scandinavian Objects

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## US & Scandinavian Objects

<table>
<thead>
<tr>
<th>Feature</th>
<th>Simula 67</th>
<th>Smalltalk 80</th>
<th>Snyder (1991)</th>
</tr>
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<tbody>
<tr>
<td>Abstraction</td>
<td>&quot;Modelling&quot;: attributes exposed</td>
<td>attributes encapsulated</td>
<td>Objects characterized by offered services</td>
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<tr>
<td>Active Objects</td>
<td>Yes</td>
<td>No</td>
<td>&quot;Associated Concept&quot;</td>
</tr>
<tr>
<td>Dynamic Objects</td>
<td>Yes</td>
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Abstraction
Abstraction: key idea of O-O

Simula doesn't mention abstraction specifically. It speaks of “modelling”
a model: an abstraction with a mission
The idea of separating the internal (concrete) and external (abstract) views of data was yet to mature.

- Hoare 1972 — Proof of Correctness of Data Representations
- Parnas 1972 — Decomposing Systems into Modules
- CLU — 1974–5 — rep, up, down and cvt
Type Abstraction ≠ Procedural Abstraction

Type Abstraction ≠ Procedural Abstraction

Don’t need types
multiple implementations can co-exist

Autognostic

Type Abstraction ≠ Procedural Abstraction

Types are essential
- exactly one implementation
  - Pasignnostic

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Type Abstraction

- Types are essential
- Exactly one implementation
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Procedural Abstraction

- Don’t need types
- Multiple implementations can co-exist
- Autognostic

Co-algebraic data types

Algebraic Data Types

Data Abstraction


Thursday, 25 August 2011
Type Abstraction ≠ Procedural Abstraction

- Types are essential
  - exactly one implementation
  - Pasignostic
- Don’t need types
  - multiple implementations can co-exist
  - Autognostic

Type Abstraction ≠ Procedural Abstraction

CLU provides ADTs: fundamentally different from objects!

Did Liskov and the CLU team realize this?

Simula’s class construct can be used to generate both records (unprotected, or protected by type abstraction) and objects (protected by procedural abstraction)

C++ can also be used to program data abstractions as well as objects
Active Objects
Active Objects

Active objects is an idea that has become lost to the object-oriented community.

Activity was an *important* part of Simula

“quasi-parallelism” was a sweet-spot in 1961

Hewitt’s Actor model [1973] built on this idea

Emerald used it [Black1986]

But activity has gone from “mainstream” O-O
Why are Smalltalk Objects passive?

I don’t know

Perhaps: Kay and Ingalls had a philosophical objection to combining what they saw as separate ideas

Or

Perhaps: The realities of programming on the Alto set limits as to what was possible

Or

Perhaps: They wanted real processes, not co-routines
Erlang Process Challenge

Put N processes in a ring:

Send a simple message round the ring M times.
Increase N until the system crashes.
How long did it take to start the ring?
How long did it take to send a message?
When did it crash?
Process-creation Times

![Graph showing process creation times on a log-log scale.](image)

- Graph title: Process creation times (LOG/LOG scale)
- X-axis: Number of processes
- Y-axis: microseconds/processor
- Lines:
  - Red: 'erlspawn.txt'
  - Green: 'javaspawn.txt'
  - Blue: 'c#spawn.txt'

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Process-creation Times

Pharo 1.1.1 on Cog
Message-passing times

Message sending times (LOG/LOG)

- 'erlmsg.txt'
- 'javamsg.txt'
- 'cmsg.txt'

Number of processes

microseconds/message

Thursday, 25 August 2011
Message-passing times

Pharo 1.1.1 on Cog

Thursday, 25 August 2011
Classes & Objects
Does Object-O mean Class-O?

Historically, most of the ideas in o-o came from the class concept.
But it’s the dynamic objects, not the classes, that form the system model.
Classes are interesting only as a way of creating the dynamic system model of interacting objects.

They are a great tool if you want hundreds of similar objects.

But what if you want just one object?
Classes are Meta

Classes are meta, and meta isn’t always betta!

- if you need one or two objects, it’s simpler and more direct to describe them in the program directly ...
- rather than to describe a factory (class) to make them, and then use it once or twice.

This is the idea behind Self, Emerald, NewtonScript and JavaScript

- Classes (object factories) can in any case be defined as objects
Types
Type Abstraction ≠ Procedural Abstraction

- **Type Abstraction**
  - Types are essential
  - exactly one implementation
  - species-knowing

- **Procedural Abstraction**
  - Don’t need types
  - multiple implementations can co-exist
  - Autognostic

Algebraic Data Types

Don’t need types
multiple implementations can co-exist
Autognostic

Thursday, 25 August 2011
Types for Objects are Optional

- Algebraic data types need types to get encapsulation.
- Objects don’t: they enjoy procedural encapsulation.

Object-oriented abstraction can exist without types.
Types are Optional

Why would one want to add type annotations to an object-oriented program?

To add *redundancy*

Type annotations are assertions just like `assert s.notEmpty`

*Redundancy is a “good thing”:*

*It provides more information for readers*

*It means that more errors can be detected sooner*
Claim: types can be harmful!
Claim: types can be harmful!

Question:
If types add redundancy, and redundancy is good, how can types be harmful?
Claim: types can be harmful!

Question:
If types add redundancy, and redundancy is good, how can types be harmful?

Answer:
Because types are too much of an invitation to mess up your language design!
Two approaches to type-checking

The “laissez faire”, or George W. Bush interpretation:

Do what you want, we won’t try to stop you. If you mess up, the PDIC will bail you out.
Two approaches to type-checking

The “laissez faire”, or George W. Bush interpretation:

Do what you want, we won’t try to stop you. If you mess up, the PDIC will bail you out.

Program debugger and interactive checker
Two approaches to type-checking

The “laissez faire”, or George W. Bush interpretation:

Do what you want, we won’t try to stop you. If you mess up, the PDIC will bail you out.
Two approaches to type-checking

The “laissez faire”, or George W. Bush interpretation:

Do what you want, we won’t try to stop you. If you mess up, the PDIC will bail you out.

The “nanny state” or Harold Wilson interpretation.

We will look after you. If it is even remotely possible that something may go wrong, we won’t let you try.
A third interpretation is useful:

The “laissez faire”, or George W. Bush interpretation

The “nanny state”, or Harold Wilson interpretation
A third interpretation is useful:

The “laissez faire”, or George W. Bush interpretation

The “nanny state”, or Harold Wilson interpretation

The “Proceed with caution”, or Edward R. Murrow, interpretation

The checker has been unable to prove that there are no type errors in your program. It may work; it may give you a run-time error.

Good night, and good luck.
Three interpretations

Under all three interpretations, an error-free program has the same meaning.

Under Wilson: conventional static typing

An erroneous program will result in a static error, and won’t be permitted to run.

Some error-free programs won’t be permitted to run.
Three interpretations

Under all three interpretations, an error-free program has the same meaning.

Under Bush: conventional dynamic typing
all checks will be performed at runtime
Even those that are guaranteed to fail
a counter-example is more useful than a type-error message
Three interpretations

Under all three interpretations, an error-free program has the same meaning

- Under Wilson, you are not permitted to run a program that \textit{might} have a type-error

- Under Bush, any program can be run, but you will get no static warnings.

- Under Murrow interpretation, you will get a mix of compile-time warnings and run-time checks.
I’m for Murrow!

I believe that the Murrow interpretation of types is the most useful for programmers

Wilson’s “Nanny Statism” is an invitation to mess up your language design!

language designers don’t want to include any construct that can’t be statically checked
SIMULA was for Murrow too!
Core Ideas of SIMULA

According to Nygaard:

1. Modelling
   The actions and interactions of the objects created by the program model the actions and interactions of the real-world objects that they are designed to simulate.

2. Security
   The behavior of a program can be understood and explained entirely in terms of the semantics of the programming language in which it is written.
SIMULA was for Murrow too!

- Modelling came first!

- SIMULA did not compromise its modelling ability to achieve security

- It compromised its run-time performance incorporating explicit checks where necessary when a construct necessary for modelling was not statically provable as safe
The “Wilson obsession”

Results in:

- type systems of overwhelming complexity
- languages that are
  - larger
  - less regular
  - less expressive
Example: parametric superclasses

class Dictionary extends Hashtable {
    method findIndex (predicate) overrides {
        ...
    }
    method at (key) put (value) adds {
        ...
    }
    ...
}

This is fine so long as Hashtable is a globally known class

But suppose that I want to let the client choose the actual class that I’m extending?
Example: parametric superclasses

```java
class Dictionary (ht) extends ht {
    method findIndex (predicate) overrides {
    ...
    }
    method at (key) put (value) adds {
    ...
    }
    ...
}
```

This is not so fine:

we need a new notion of “heir types” so we can statically check that arguments to Dictionary have the right properties
Example: parametric superclasses

This is not so fine:

we need a new notion of “heir types” so we can statically check that arguments to Dictionary have the right properties

Or:

we need a new function & parameter mechanism for classes

Or:

we ban parametric superclasses, add global variables, add open classes, and still decrease usability

Or:
Virtual Classes

Virtual classes, as found in BETA, are another approach to this problem

They feature co-variant methods

methods whose arguments are specialized along with their results

Not statically guaranteed to be safe

Nevertheless, useful for modelling real systems
Example: type parameters

Types need parameters, e.g.,

\texttt{Set.of (Informatician)}

where \texttt{Informatician} is another type

Obvious solution:

Represent types as Objects, and use the normal method \& parameter mechanism.

Bad news: type checking is no longer decidable
Type-checking is not decidable!

Murrow Reaction:
So what? Interesting programs will need some run-time checking anyway.
Type-checking is not decidable!

Murrow Reaction:
So what? Interesting programs will need some run-time checking anyway.

Wilson Reaction:
Shock! Horror! We can’t do that!

- Invent a new parameter passing mechanism for types, with new syntax, and new semantics, and a bunch of restrictions to ensure decidability
- Some programs will still be untypeable (Gödel)
- Result: language becomes larger, expressiveness is reduced.
The Future of Objects
(according to Black)
Current Trends in Computing

- Multicore → Manycore
- Energy-Efficiency
- Mobility and “the cloud”
- Reliability
- Distributed development teams
Multicore and Manycore

What do objects have to offer us in the era of manycore?

Processes interacting through messages!
A Cost Model for Manycore

Most computing models treat computation as the expensive resource it was so when those models were developed!

    e.g. moving an operation out of a loop is an “optimization”

Today: computation is free

    it happens “in the cracks” between data fetch and data store

Data movement is expensive both in time and energy
A Problem:

Today’s computing models can’t even express the thing that needs to be carefully controlled on a manycore chip:

Data movement
A Cost Model for Manycore

Spatial arrangement of Small Objects
small method suite as well as small data
local operations are free
optimization means reducing the size of the object, not the number of computations
message-passing is costly
cost of message = (amount of data) x (distance)
the “message.byte.nm” model
Mobility and the Cloud

Fundamentally relies on replication and caching for performance and availability

Do Objects help?

Best model for distributed access seems to be (distributed) version control

svn, Hg, git

Can we adapt objects to live in a versioned world?

Object identity is problematic
Object references in a Versioned world

Learn from Erlang:

Erlang messages can be sent to a `prosessId`, or to a `processName` (“controllerForArea503”)

Perhaps: we should be able to reference objects *either* by a descriptor

  e.g. “Most recent version of the Oslo talk”

*or*

by an Object id?

  `Object16x45d023f`
Reliability

Failures are always partial

What’s the unit of failure in the object model?

Is it the object, or is there some other unit?

Whatever it is must “leak failure”

How to mask failure:

replication in space

replication in time
Distributed Development Teams

What’s this to do with objects?
Packaging!

Collaborating in loosely-knot teams demands better tools for packaging code

All modules are parameterized by other modules

No global namespace?

URLs as the global namespace?

Versioned objects as the basis of a shared programming environment?
Algol 60 and Simula:

Dahl recognized that *the runtime structures of Algol 60* already contained the mechanisms that were necessary for simulation.

It is the *runtime behavior* of a simulation system that models the real world, *not* the program text.
Agile Design:

Agile software development is a methodology in which a program is developed in small increments, in close consultation with the customer.

The code runs at the end of the first week, and new functions are added every week.

How could this possibly work! Isn’t it important to design the program?

Yes! Design is important. It’s so important, we don’t do it only when we know nothing about the program. We design every day. The program is continuously re-designed as the programmers learn from the behavior of the running system.
Insight:

- The program’s run-time behavior is what matters!
  - This is obvious if programs exist to control computers; less so, if programs are system descriptions

- Program behavior, not programs, model real-world systems

- The program-text is a meta-description of the program behavior.

- It’s not always easy to infer the behavior from the meta-description
Observation:

- I know that I have succeeded as a teacher when students anthropomorphize their objects.
- This happens more often and more quickly when I teach with Smalltalk than when I teach with Java.
- Smalltalk programmers talk about objects, Java programmers talk about classes.

*Why is this?*
The Value of Dynamism:

* Smalltalk is a “Dynamic Language”
  * Many features of the language and the programming environment help the programmer to interact with objects, rather than with code

* Proposed definition: a “Dynamic Programming Language” is one designed to facilitate the programmer learning from the run-time behavior of the program.
What are the major concepts of object-orientation?

- it depends on the social and political context!

After 50 years, there are still ideas in SIMULA to be mined to solve 21st century problems.

1000 years from now, there may not be any programming,

but I’m willing to wager that Dahl’s ideas will still, in some form, be familiar to programmers in 2061.