Teaching Principles!
Which Principles?

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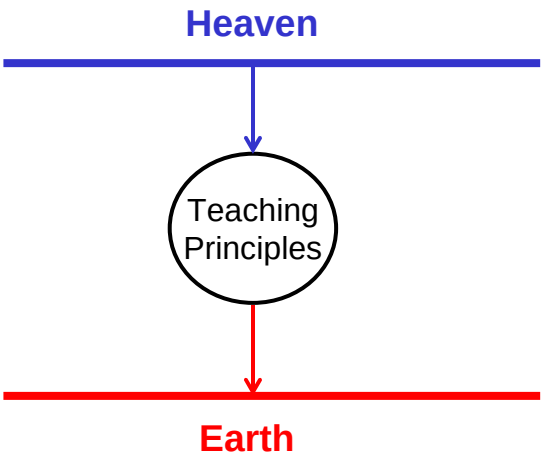
On the Level of Teaching



Four Principles

- Stepwise refinement
- Information hiding
- Software composition
- Programming model

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- Information hiding
- Software composition
- Programming model

"With a new computer language, one not only learns a new vocabulary and grammar but one opens oneself to an new world of thought"

Niklaus Wirth

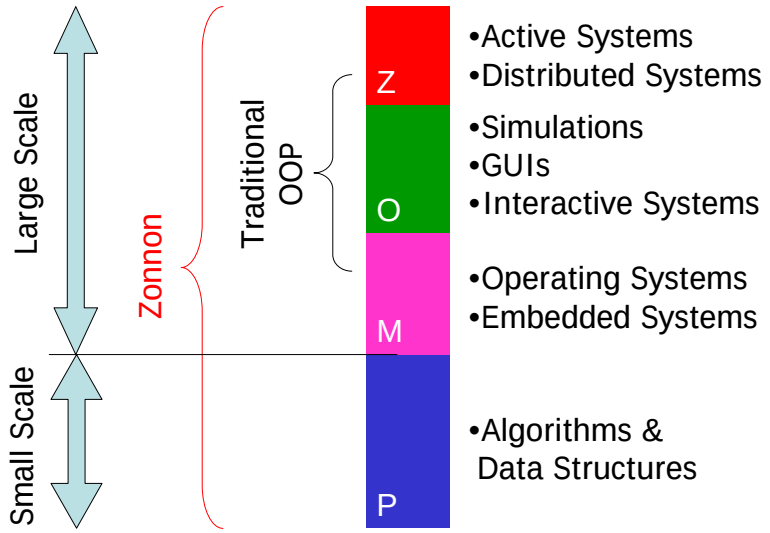
The Pascal Language Family

- Guiding Principle: „Make it as simple as possible but not simpler"

	Language	New Feature	Concept
1970	Pascal	Pointer	A&D
1980	Modula	Module	Systems
1990	Oberon	Type Extension	OOP
2005	Zonnon	Activity	Concurrency

- The Zonnon project has emerged from MS Project 7/7+ initiative
  http://zonnon.ethz.ch

Spectrum of Programming



A Simple A&D Zonnon Program

```
module Zeller;
  procedure { public } getWeekDay;
    var
      d, m, y, c, n: integer;
      wd: array 7 of string;
  begin
    readln(d, m, y);
    c := y div 100;
    y := y mod 100; m := m - 2;
    n := entier(2.62*m - 0.2)
      + d + y + y div 4 + c div 4 - 2*c
    writeln(wd[n mod 7])
  end getWeekDay;
begin
  wd[0] := "Sunday"; wd[1] := "Monday";
  wd[2] := "Tuesday"; wd[3] := "Wednesday";
  wd[4] := "Thursday"; wd[5] := "Friday";
  wd[6] := "Saturday"
end Zeller.
```

no classes,
no objects,
no inheritance,
no virtual methods,
no overriding,
no static fields

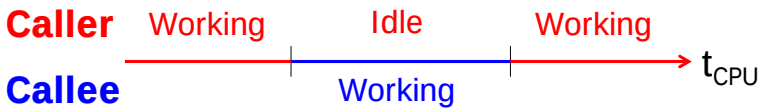
The Challenge of Concurrency

- Moore's Law
  - Double performance each 1.5 years
- Achieved via
  - Until now: # FLOPS
    - 10 MHz → 100 MHz → 1 GHz → 3.2 GHz
    - Power, Heat ⇒ Stop at ≈ 3.5 GHz
  - From now: Multi CPU cores
    - 1 CPU → 2 CPU → 8 CPU →
- Challenge of exploiting multiple CPU
  - Support needed from programming language

The Zonnon Programming Model: A Structured Approach to Concurrency

Procedural Paradigm

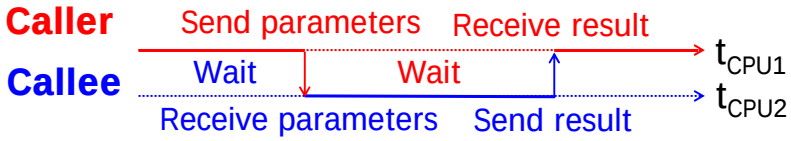
- Directed at single CPU configurations



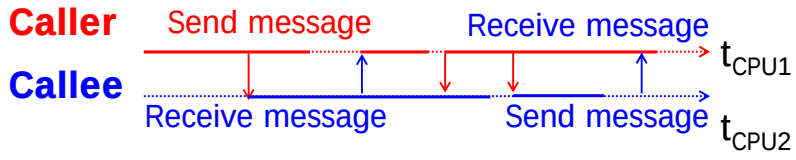
- The same paradigm used in different cases
  - Local procedure call
  - Method call
  - Remote procedure call

New Concept: Activities

- Procedure call as dialog



- Activities as generalized procedures



Scenario 1: Independent Actions

```
• activity A ( … );
    var …
  begin …
  end A;
• activity B ( … );
    var …
  begin …
  end B;
• begin { barrier }
    new A(…); new B(…)
  end
```

Example 1: Quicksort

```
• activity Sort (l, h: integer)
    var i, j: integer;
  begin { barrier }
    … (*partition array l, j & i, h*)
    if l < j then new Sort(l, j) end;
    if i < h then new Sort(i, h) end
  end Sort;
• (*start Quicksort*)
  begin
    new Sort(1, N)
  end
```

Example 2: Active Objects

```
• type X = object
    activity A (…);
      … (*intrinsic behavior*)
    end A;
    activity B (…);
      … (*intrinsic behavior*)
    end B;
    procedure new (…);
      … (*constructor*)
    end new;
  begin { barrier }
    new A(…); new B(…)
  end X;
```

Passive vs. Active

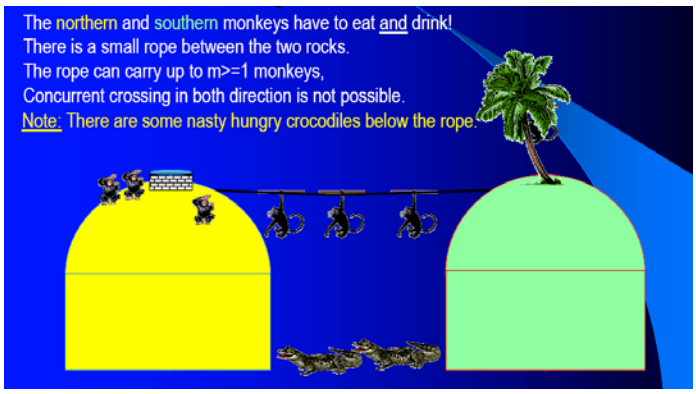
put item
get item

set time
get time

Scenario 2: Object Dialogs

- ```
  type Y = object (*callee*)
    activity D (…): …;
      var t, u: T;
    begin (*dialog*)
      … return t; … u := *; …
    end
  end Y;
  ```
- ```
  var y: Y; d: Y.D; t, u: T;
  begin (*caller*)
    y := new Y;
    d := new y.D; (*active link*)
    t := d(…); … d(u); …
  end
  ```

Example 1: World of Monkeys



The Rope as Shared Resource

```
• module { shared } Rope; (*global view*)
    type
      Monkey = object; (*active*)
      MonkeyMsg = (claim, release);
    var cur, i: integer;
      (*number of monkeys on rope
        > 0 South-North traversal
        < 0 North-South traversal*)
    activity MonkeyDialog (): MonkeyMsg;
  begin
    for i := 0 to 99 do new Monkey () end
  end Rope;
```

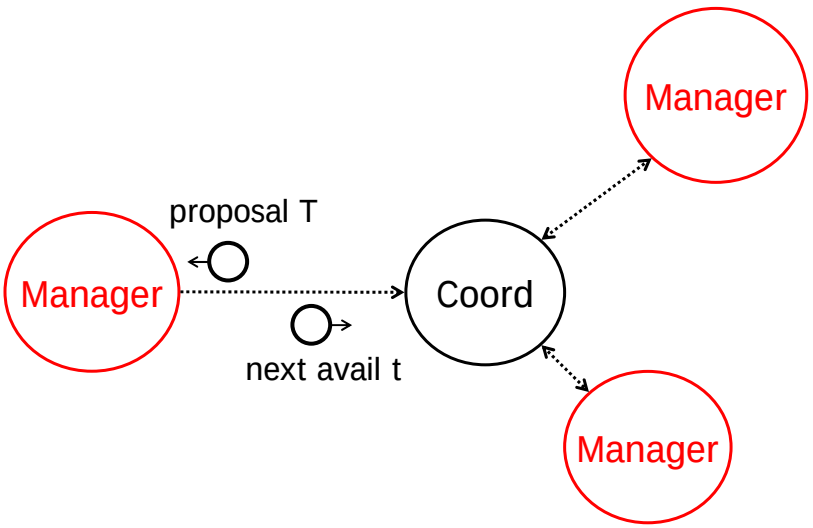
Monkeys as Active Objects

```
• type Monkey = object
    activity LiveOnTheRocks ();
      var res: MonkeyMsg;
        d: Rope.MonkeyDialog;
    begin (*story of life*)
      d := new Rope.MonkeyDialog;
      loop
        passivate(Random.Next()); (*eat/dr*)
        res := d(MonkeyMsg.claim);
      end
    end LiveOnTheRocks;
  begin { barrier }
    new LiveOnTheRocks()
  end Monkey;
```

The Monkey Dialog Activity

```
• activity MonkeyDialog (): MonkeyMsg;
    var req: MonkeyMsg;
  begin
    loop
      req := *; (*South-North request*)
      await (0 <= cur) & (cur < m);
      inc(cur); passivate(100);
      dec(cur); return MonkeyMsg.release;
      req := *; (*North-South request*)
      await (0 >= cur) & (cur > -m);
      dec(cur); passivate(100);
      inc(cur); return MonkeyMsg.release
    end
  end MonkeyDialog;
```

Example 2: Next Meeting Time



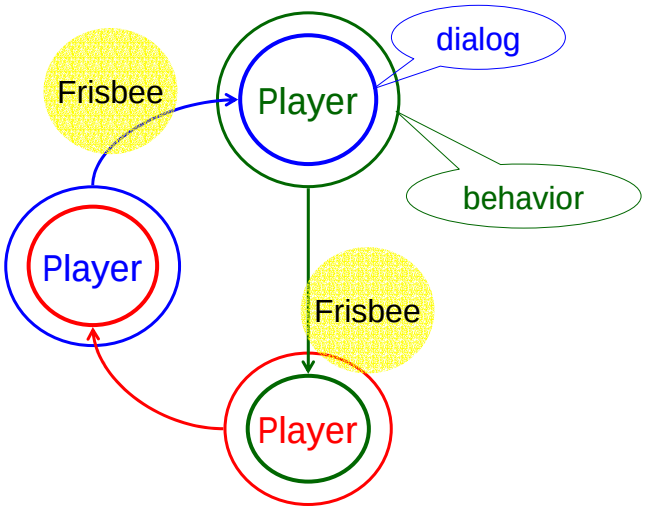
The Coordinator

```
module { shared } Coordinator;
  type Manager = object; (*active*)
  var T, i: integer;
  activity ManagerDialog ();
    var next: integer;
  begin
    loop
      return T; t := *;
      if t > T then T := t end;
      await T > t;
    end
  end ManagerDialog;
begin T := 0;
  for i := 0 to 9 do new Manager() end
end Coordinator.
```

Managers as Active Objects

```
type Manager = object
  activity Check ();
    var t: integer;
      d: Coordinator.ManagerDialog;
  begin
    d := new Coordinator.ManagerDialog;
    loop
      t := d();
      (*check agenda and update t*)
      d(t)
    end
  end
begin new Check()
end Manager;
```

Example 3: Frisbee Fun



Starting the Game

```
• module Game;
    type Player = object; (*active*)
    var i: integer; p, q, last: Player;
  begin
    last := new Player(); q := last;
    for i := 0 to 9 do
      p := new Player ();
      p.Init(q, Random.Next() mod 2);
      q := p
    end;
    last.Init(q, 0)
  end Game.
```

Player as Dual Activity Object

```
type Player = object { shared }
  FrisbeeMsg = (request, catch);
  var nofFrisbees: integer;
    d: Player.FrisbeeDialog;
  procedure Init (q: Player; f: integer);
  begin
    d = new q.FrisbeeDialog;
    nofFrisbees = f;
  end Init;
  activity Play ();
  activity FrisbeeDialog (): FrisbeeMsg;
begin { barrier }
  new Play ()
end Player;
```

The Playing Activity

```
activity Play ();
  var msg: FrisbeeMsg;
begin
  d := new Player.FrisbeeDialog;
  loop
    await nofFrisbees # 0;
    msg := d(); d(FrisbeeMsg.catch);
    nofFrisbees := 0
  end
end Play;
```

The Frisbee Dialog Activity

```
activity FrisbeeDialog ();
  var msg: FrisbeeMsg;
begin
  loop
    await nofFrisbees = 0;
    return FrisbeeMsg.request;
    msg := *;
    nofFrisbees := 1
  end
end FrisbeeDialog;
```

Example 4: Santa Claus

- Invented by John Trono in „J. A. Trono. A new exercise in concurrency. SIGCSE Bulletin, 1994“
- Discussed and solved later by Ben-Ari with Rendez-Vous (in Ada95) and monitors (in Java)

The Original Story

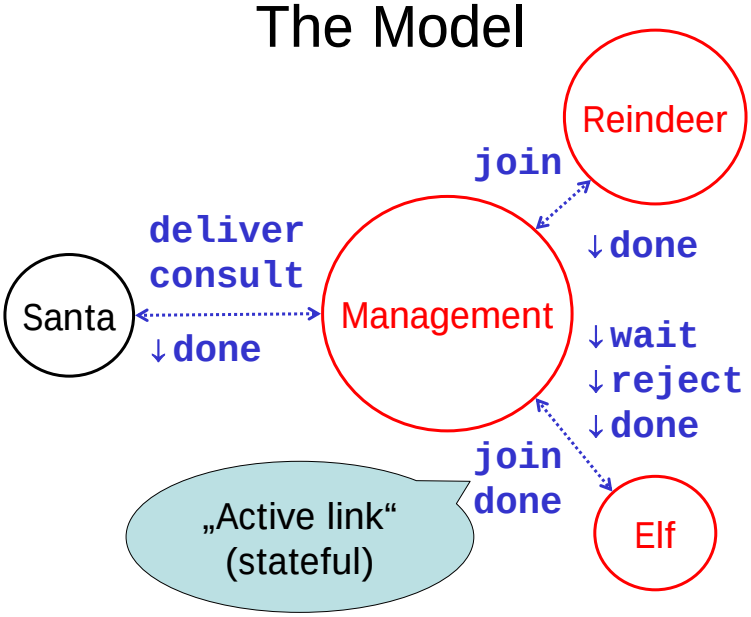
- Santa Claus sleeps at the North pole until awakened by either all of the nine reindeer, or by a group of three out of ten elves. He performs one of two indivisible actions:
  - If awakened by the group of reindeer, Santa harnesses them to a sleigh, delivers toys, and finally unharnesses the reindeer who then go on vacation.
  - If awakened by a group of elves, Santa shows them into his office, consults with them on toy R&D, and finally shows them out so they can return to work constructing toys.
- A waiting group of reindeer must be served by Santa before a waiting group of elves. Since Santa's time is extremely valuable, marshalling the reindeer or elves into a group must not be done by Santa.

Our Extension: Negotiation

- Before joining, elves should be informed about the expected waiting time and be given the opportunity to withdraw
- Dialog as formal syntax in EBNF
  - Messages from callee to caller marked " ↓ "

```
HandleElf = join ( Negotiate  | ↓reject ).
Negotiate = [ ↓wait join ] ↓done |
 ↓wait done.
```

The Model



Management as Active Server

```
• module { shared } Management;
    type
      ElfMsg = (join, reject, delay, done);
      ReindeerMsg = (join, done);
      SantaMsg = (deliver, consult, done);
      Elf = object; (*active*)
      Reindeer = object; (*active*)
      Santa = object;
    var r0, r, R, e0, e, E: integer;
      santa: Santa;
    activity Work ();
    activity ElfDialog (): ElfMsg;
    activity ReindeerDialog (): ReindeerMsg;
  begin { barrier }
    new Work ()
  end Management.
```

Manager as Active Server

```
activity Work ();
  var res: SantaMsg;
    d: Santa.Dialog;
begin
  d := new santa.Dialog;
  loop
    await (r > r0) & (e > e0);
    if r > r0 then
      res := d(SantaMsg.deliver); inc(r0)
    else
      res := d(SantaMsg.consult); inc(e0)
    end
  end
end Work;
```

The Elf Handling Activity

```
activity ElfDialog ();
  var myGroup: integer; req: ElfMsg;
begin
  loop req := *;
    if (*too soon*) then return ElfMsg.reject
    else
      if e0 < e then
        return ElfMsg.wait; req := *
      end;
      if req = ElfMsg.join then
        myGroup = e; inc(E);
        if E = 3 then E := 0; inc(e) end;
        await e0 > myGroup;
        return ElfMsg.done
      end
    end
  end
end ElfDialog;
```

Elves as Active Objects

```
• type Elf = object
    activity Work ();
      var res: ElfMsg; d: Manager.ElfDialog;
    begin
      d := new Manager.ElfDialog;
      loop
        passivate(Random.Next());
        res := d(ElfMsg.join);
        if res = ElfMsg.wait then
          if (*impatient*) then d(ElfMsg.done)
            else res := d(ElfMsg.join)
          end
        end
      end
    end Work;
  begin { barrier } new Work()
  end Elf;
```

Santa Dialog Controlled

```
• type Santa = object
    activity Dialog (): SantaMsg;
      var req: SantaMsg;
    begin
      loop
        req := *;
        if req = SantaMsg.deliver then
          passivate(10000)
        else (*consult*) passivate(500)
        end;
        return SantaMsg.done
      end
    end Dialog;
  end Santa.
```

Summary (1)

- The presented concept of activity upgrades the ordinary object-oriented model in three respects by adding
  - An option of orchestrating multiple concurrent activities according to programmed „launch logic“
  - Optional intrinsic encapsulated behavior of objects
  - A new way of dialog-oriented and stateful interoperability based on „active links“

Summary (2)

- The concept of activity has proved its suitability in several case studies and in implementations
  - The model of active objects underlies the *Aos Active Oberon* operating system
  - Active objects and dialogs have been implemented in the *Active C# ROTOR* compiler available from http://www.avocado.ethz.ch/ActiveCSharp/
  - Activities are currently being implemented in the *Zonnon for .NET* compiler, see http://zonnon.ethz.ch