A Programmable Structure for Pervasive Computing

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Outline

1. Problems

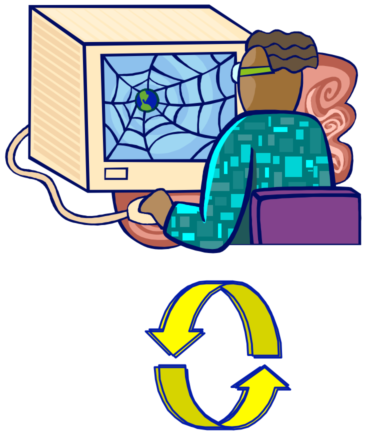
2. The WAIF approach

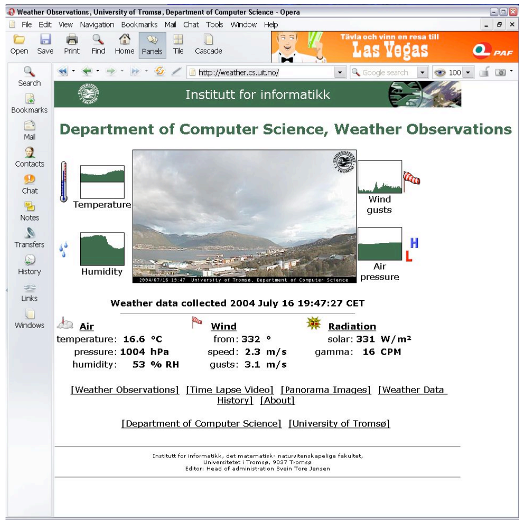
3. WAIF implementations

4. Lessons learned

1. Problems

- *Inherited structure* from the initial Internet: client-server.





Weather Observations, University of Tromsø, Department of Computer Science - Opera

http://weather.cs.uit.no/

Institutt for informatikk

Department of Computer Science, Weather Observations

2004/07/16 19:47 University of Tromsø, Department of Computer Science

Weather data collected 2004 July 16 19:47:27 CET

Air		Wind		Radiation	
temperature:	16.6 °C	from:	332 °	solar:	331 W/m²
pressure:	1004 hPa	speed:	2.3 m/s	gamma:	16 CPM
humidity:	53 % RH	gusts:	3.1 m/s		

[Weather Observations] [Time Lapse Video] [Panorama Images] [Weather Data History] [About]

[Department of Computer Science] [University of Tromsø]

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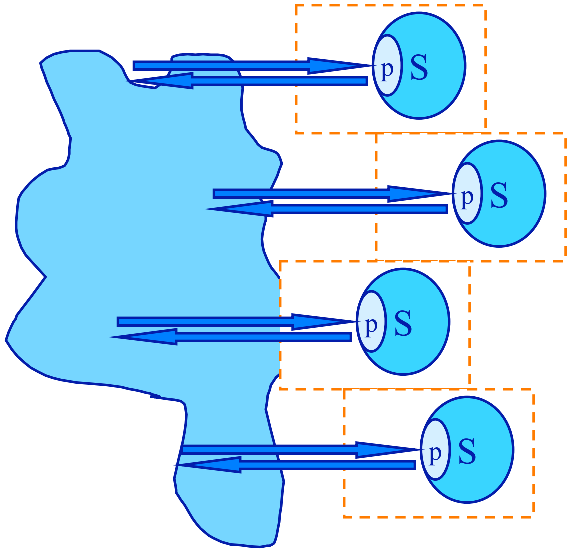


- Fact: interaction model that *takes (user) time*.

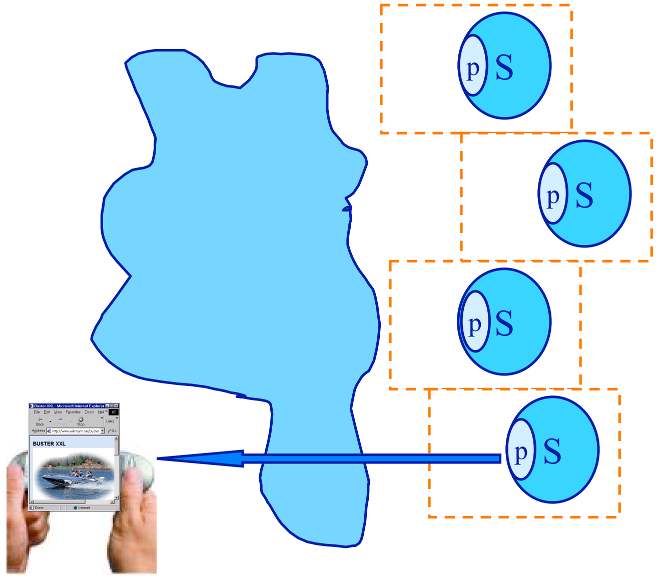
1. Towards a Proactive Internet

- We conjecture that the Web's next paradigm shift will include a much more *proactive* computing model.

- This will transform a passive web being searched by users, to information and service providers *searching actively* for users.

1. Proactive Internet

- The web works autonomously on your behalf and notifies you.



<u>Goals</u>:

- High recall.
- Extreme precision.
- Context-aware.
- Real-time.

2. WAIF (Wide Area Information Filtering)

- Problem:

  ”*How to structure the next generation web.*”

- International cooperation:

  University of Tromsø, Cornell University, and UC San Diego.

2. WAIF Principles

- Approaches:
  1. *Proactive computing* combined with high precision:

     → humans not in the loop, but above the loop.

  2. Use the network as a *personal* computer:

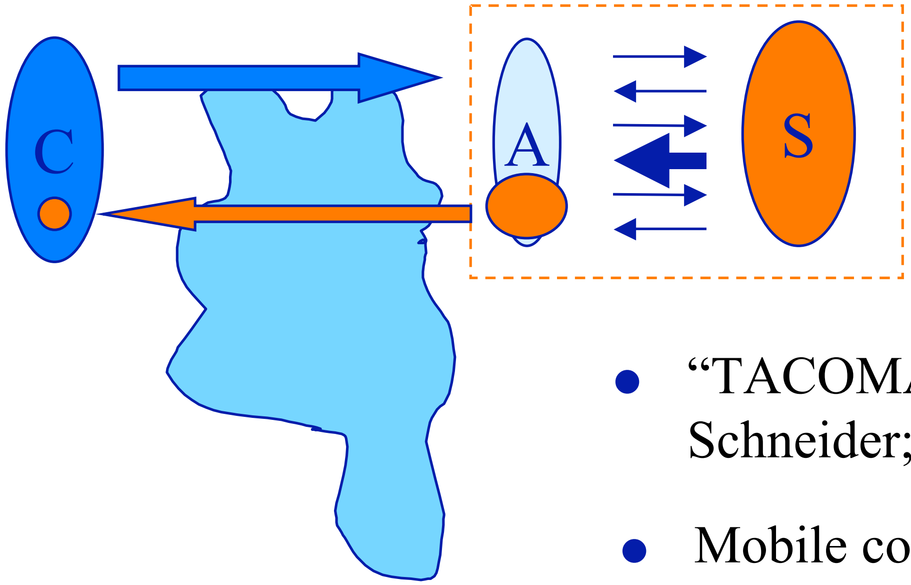
     → a single user should have his private push-based network.

  3. Mobile users in a pervasive computing environment:

     → design for mobility.

2. Extensible Servers

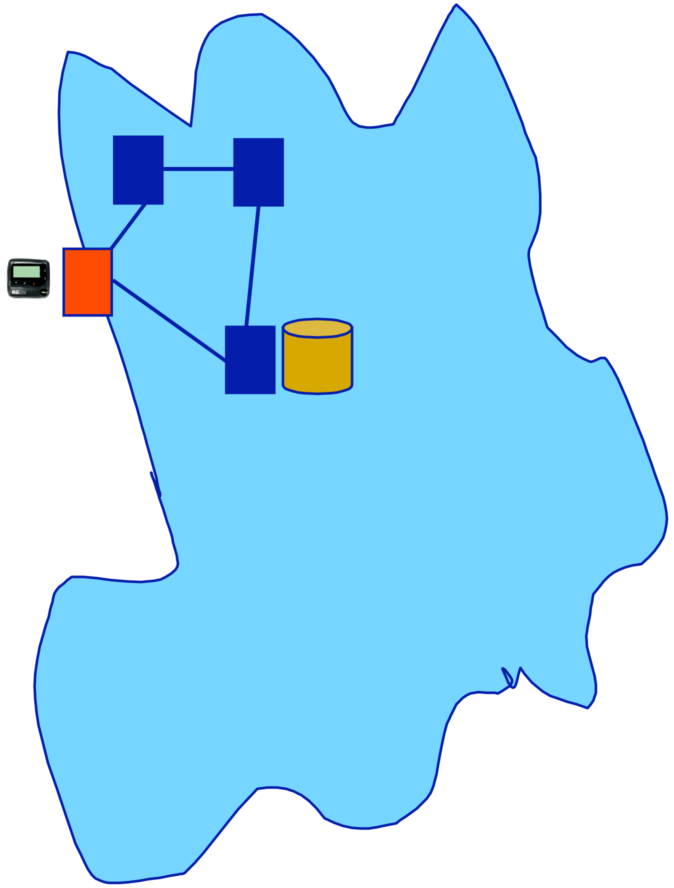
- Mobile code: suitable for run-time software installation _ *extensible servers.*



- “TACOMA”; Johansen, van Renesse & Schneider; 1994.
- Mobile code: program and install autonomous code (A: Python, C, Perl, Tcl, Java, Scheme) and data at remote servers.
- Current WAIF servers use the TOS kernel, http://tos.sourceforge.net/

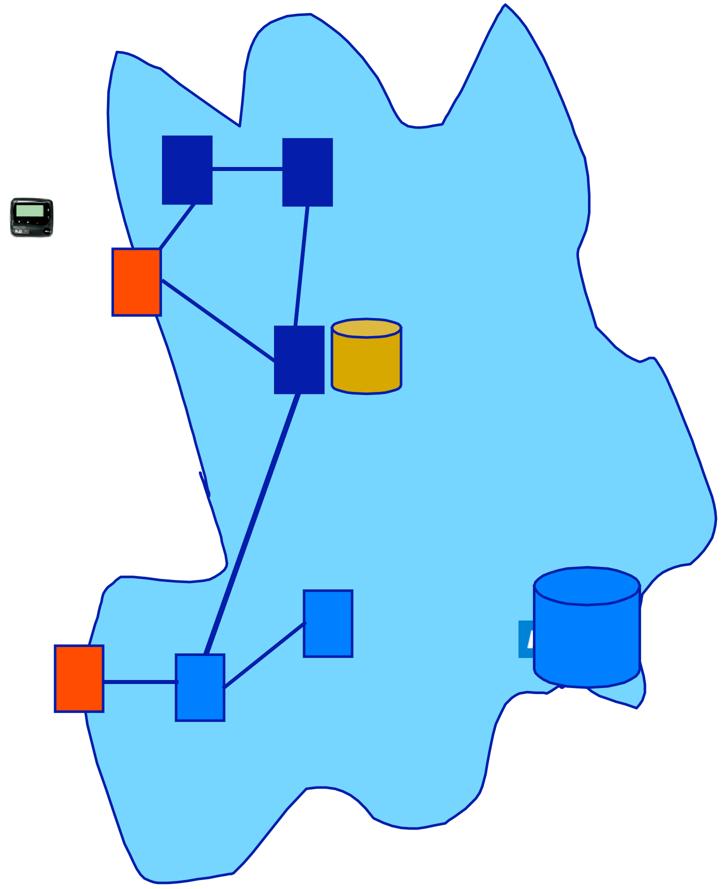
2. Software Architecture

- Pervasive computing: environment saturated seamlessly with computers, sensors and communication facilities.

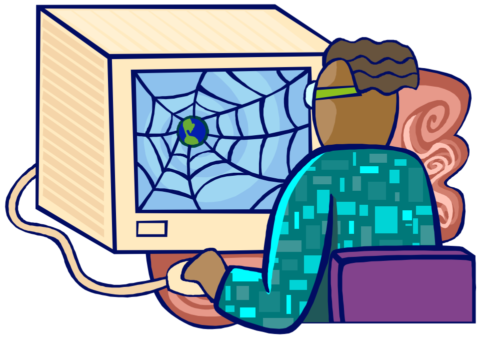


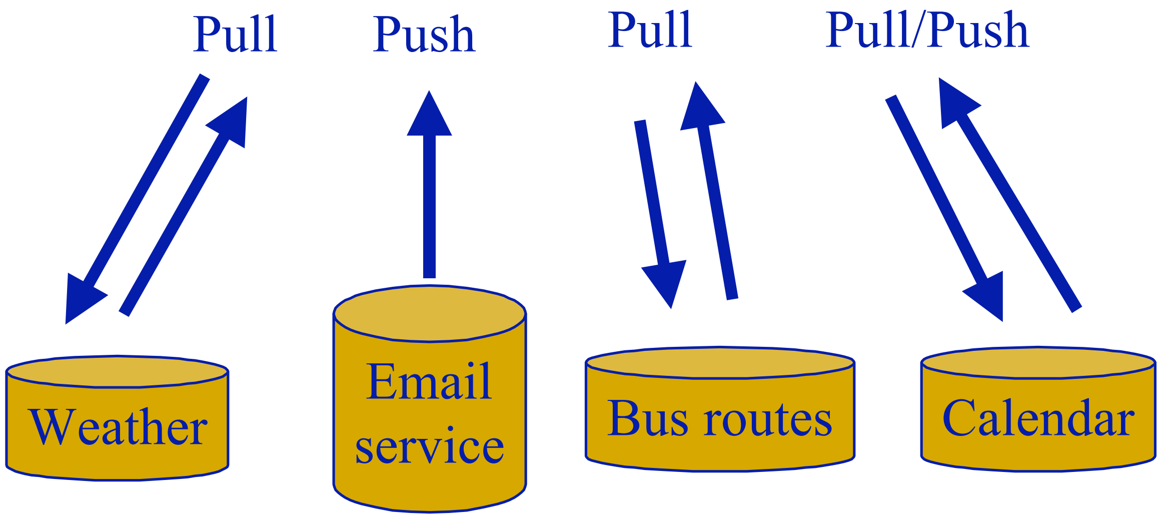
2. Software Architecture

- Pervasive computing: environment saturated seamlessly with computers, sensors and communication facilities.
- Mobile agent lessons: Install software components remotely. Single-hop agents the normal case, multi-hop the special case.
- Run-time configuration renting services from the environment (3'rd parties).

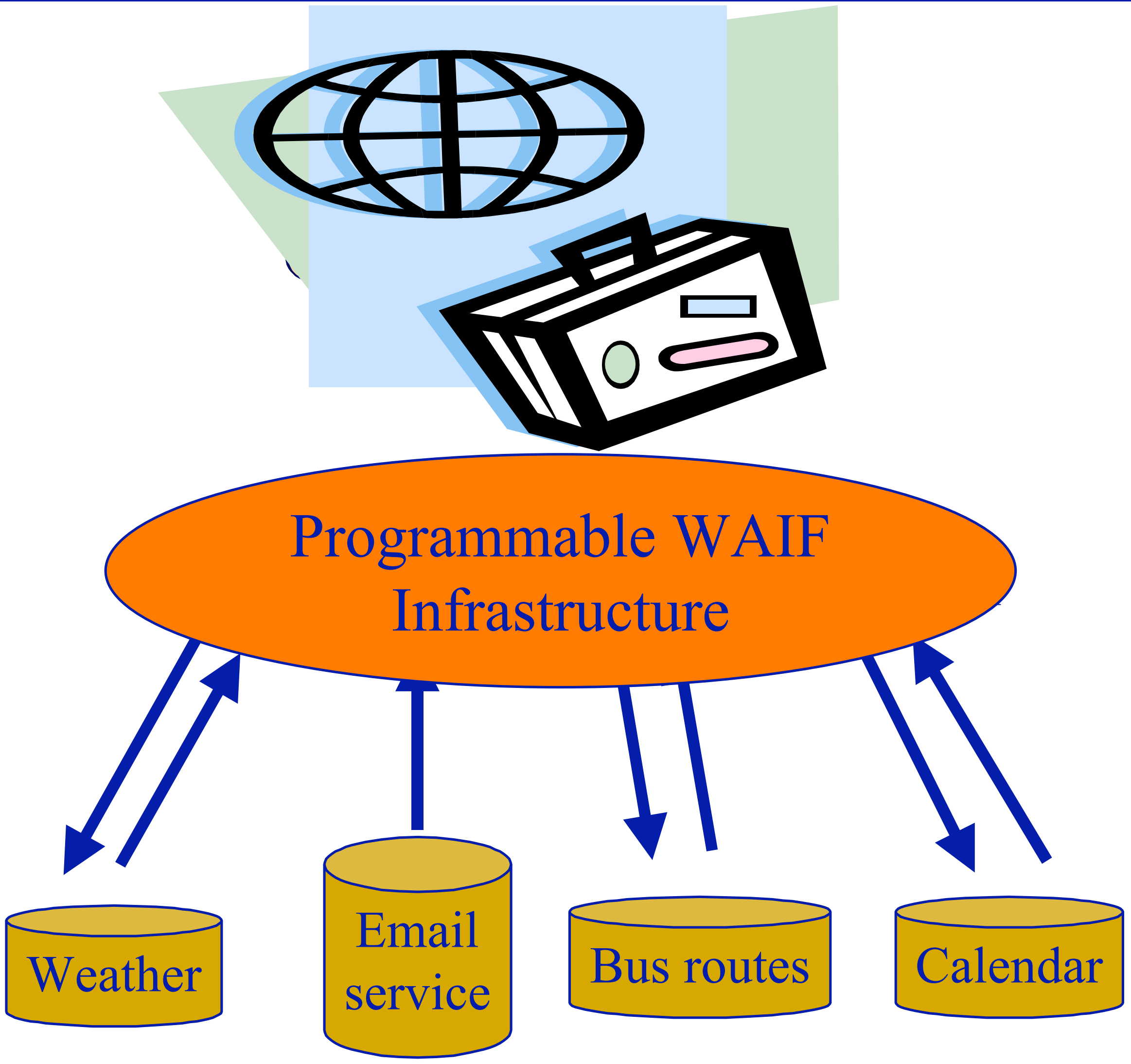


3. Today's Interaction Model





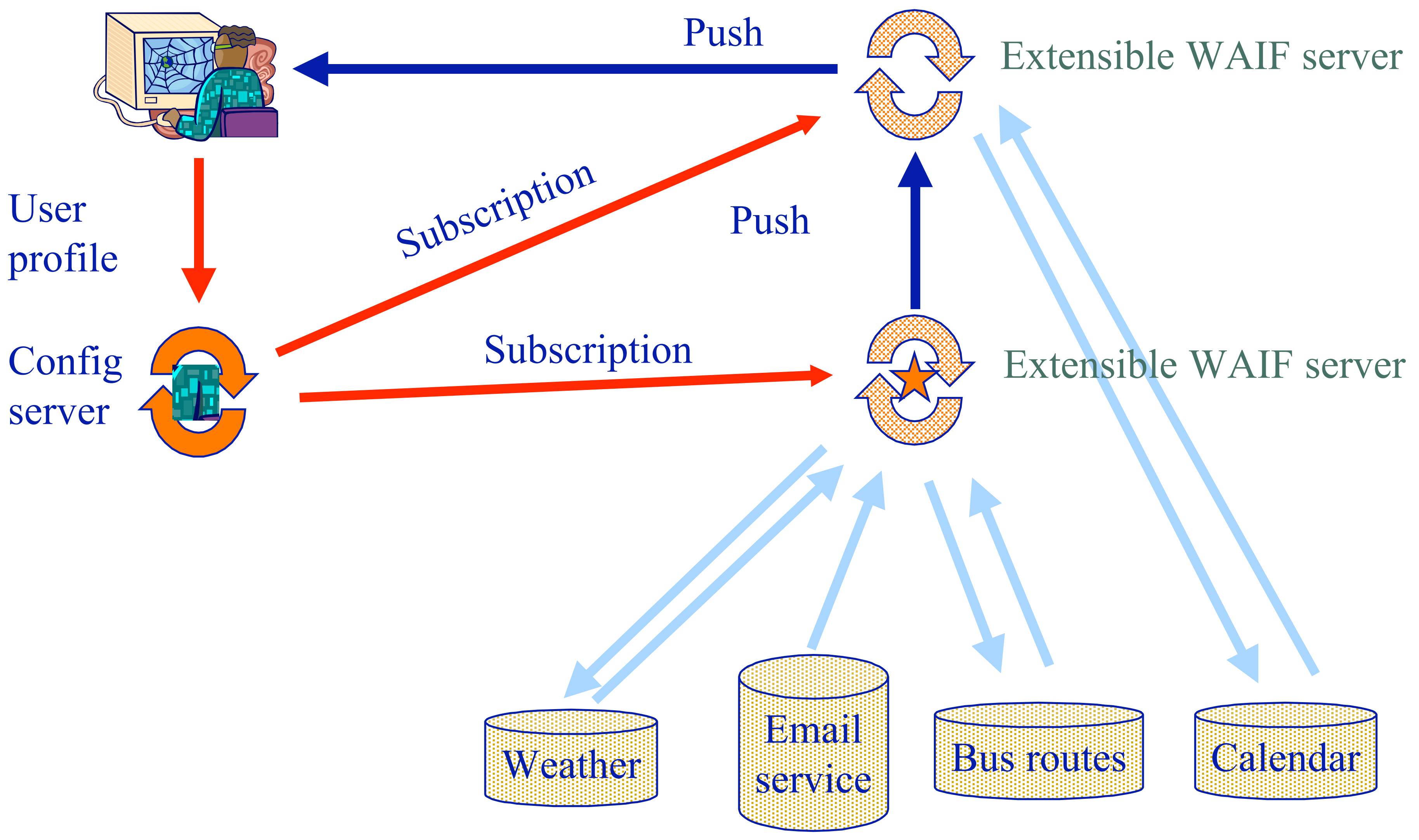
3. The WAIF Approach



3. Programming a WAIF Infrastructure

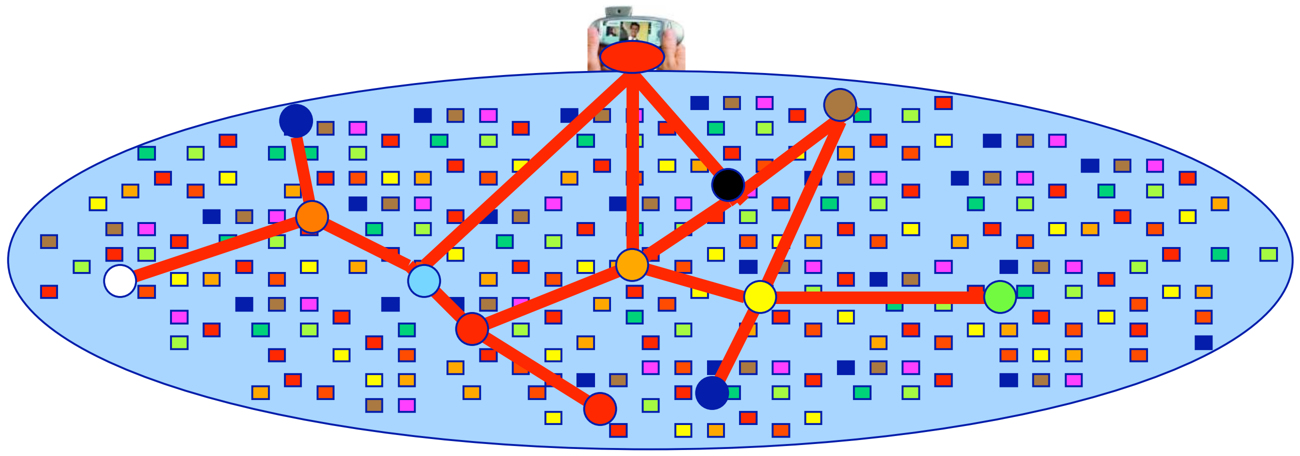
- Extensible and programmable servers.
- Programmed by expressive mobile code (filters).
- Filters extend server functionality, either user-specific or globally.
- No explicit programming required for novice Internet users.

3. Programming a WAIF Infrastructure

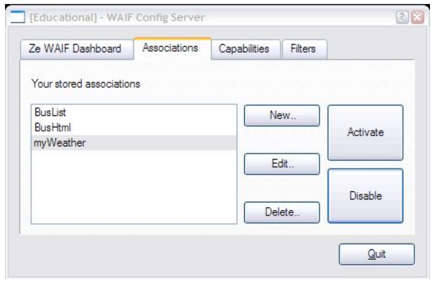


3. ”Personal Overlay Network System”

- Locate extensible servers and create your personal distributed system as an overlay network (*PONS*).



3. PONS Configuration

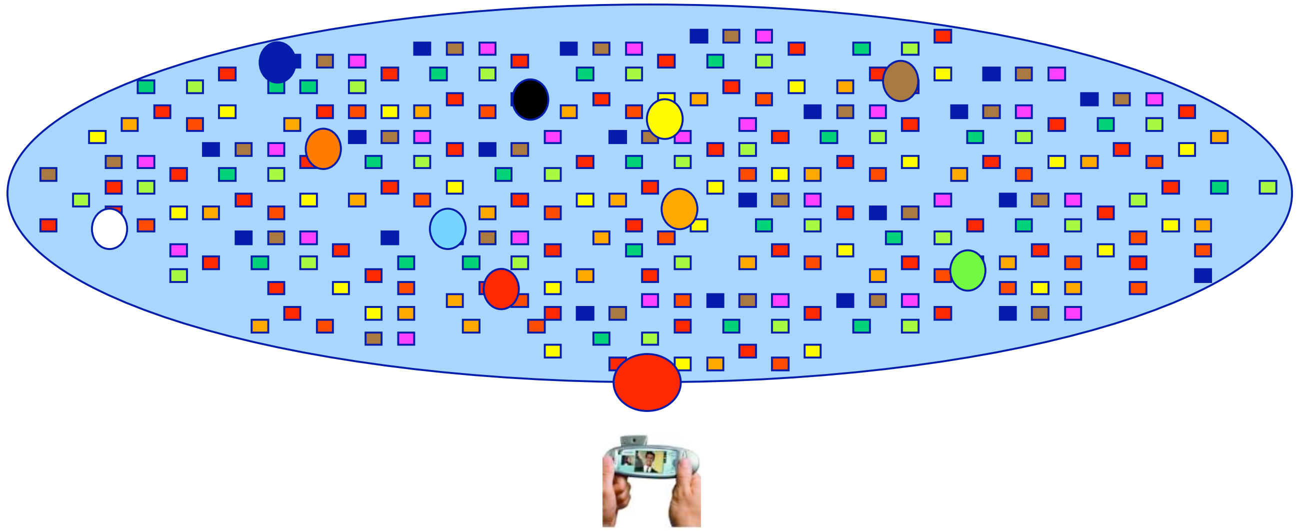

[Educational] - WAIF Config Server

Ze WAIF Dashboard | Associations | Capabilities | Filters

Your stored associations

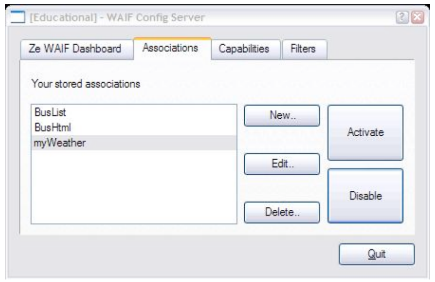
BusList
BusHtml
myWeather

New.. | Edit.. | Delete.. | Activate | Disable | Quit



- No programming required for novice internet users
- User profile automatically mapped to overlay network structure

3. PONS Event Filtering and Routing


[Educational] - WAIF Config Server

Your stored associations

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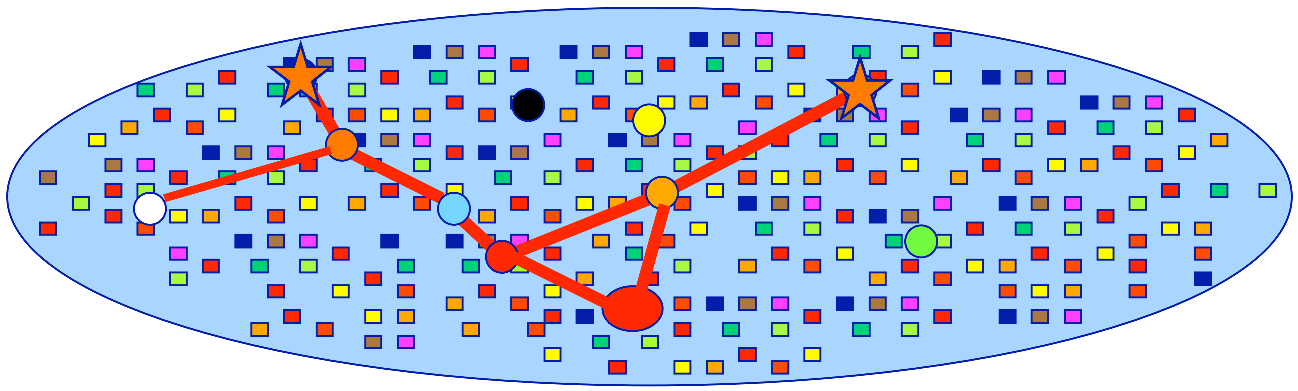

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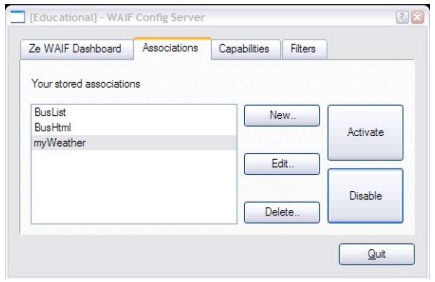
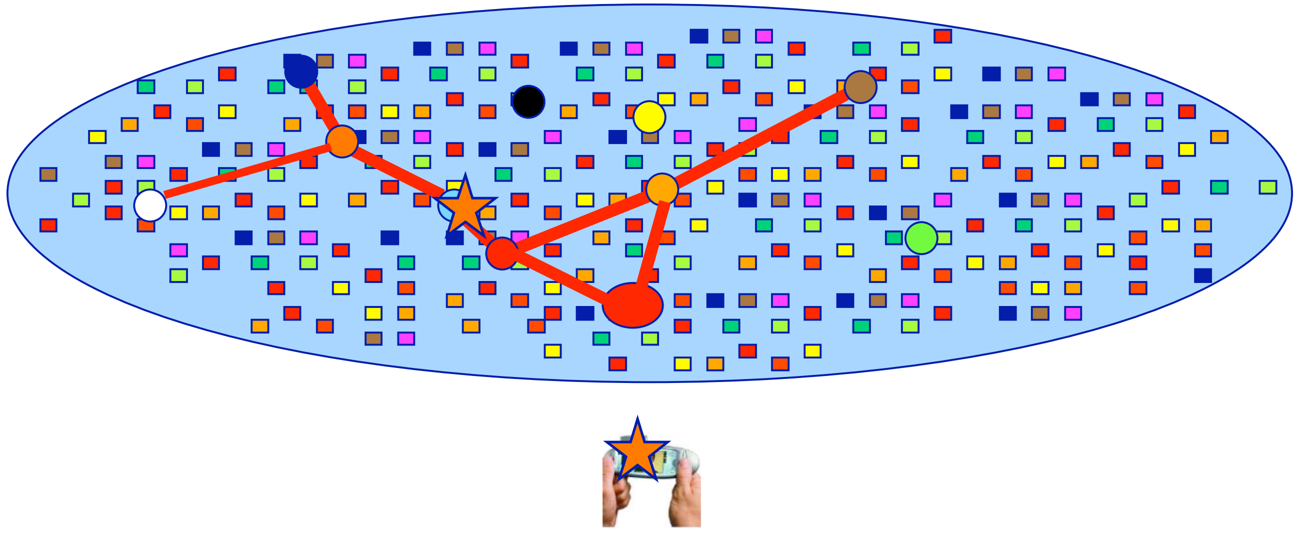
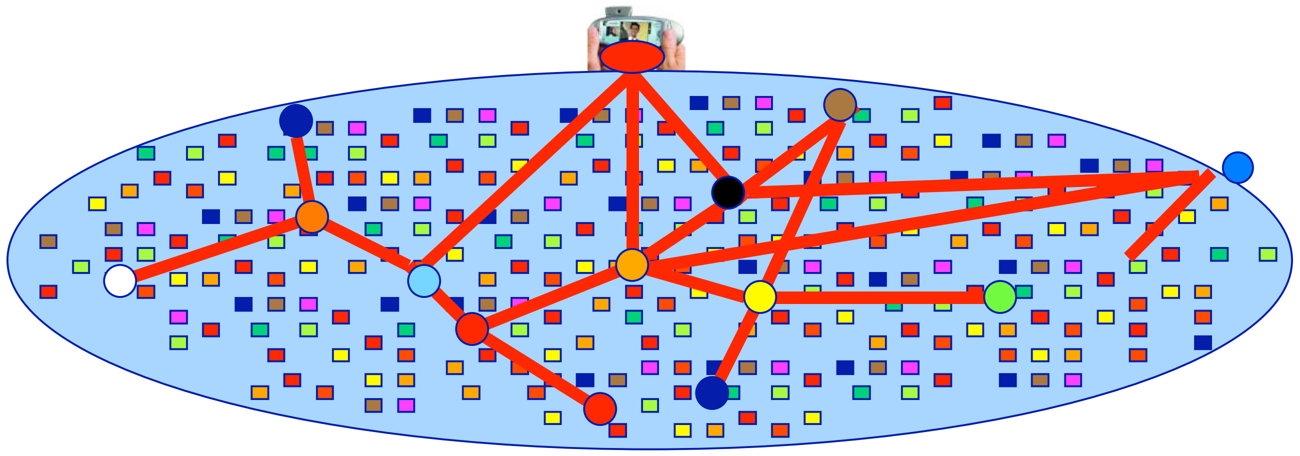




3. Supporting Mobile Users

- Move *user environments* transparently along.



- WAIFARER: Task migration for legacy applications
  - move the desktop around http://waifarer.sourceforge.net

3. Example Filter Programs

- Python code:

```
event = self.in.get()                              #upon msg: mk event
if self.check_importance(event) >= self.alertlevel:
    self.out.push(event)                                 #deliver ICPS
event
else:
    self.buffer.put(event)                         #wait for new orders
```

- Key:value dictionary:

  { userID='rharaty',
  datatype='ICPS2004',
  filter='myICPSFilter',
  alertlevel = HIGH
  }

3. WAIF Server Internals

- Python SOAP-RPC
  - Synchronous delivery, asynchronous handling.
  - Fault tolerance mechanisms.
  - Could perhaps also use JXTA

- Servers are instances of the downloadable `WAIFService` Python package.
  - http://waif.cs.uit.no/downloads

3. WAIFService Package

1. Init package.
2. Register custom event handlers.
3. `self.run()`

- Example custom event handler:

```
def busroute_handler(self, event):
   unpack (event)
   profile = self.users(user)
   self.push( address, subID,
              self.getroute(profile, event)
            )
```

3. WAIF Server Exported API

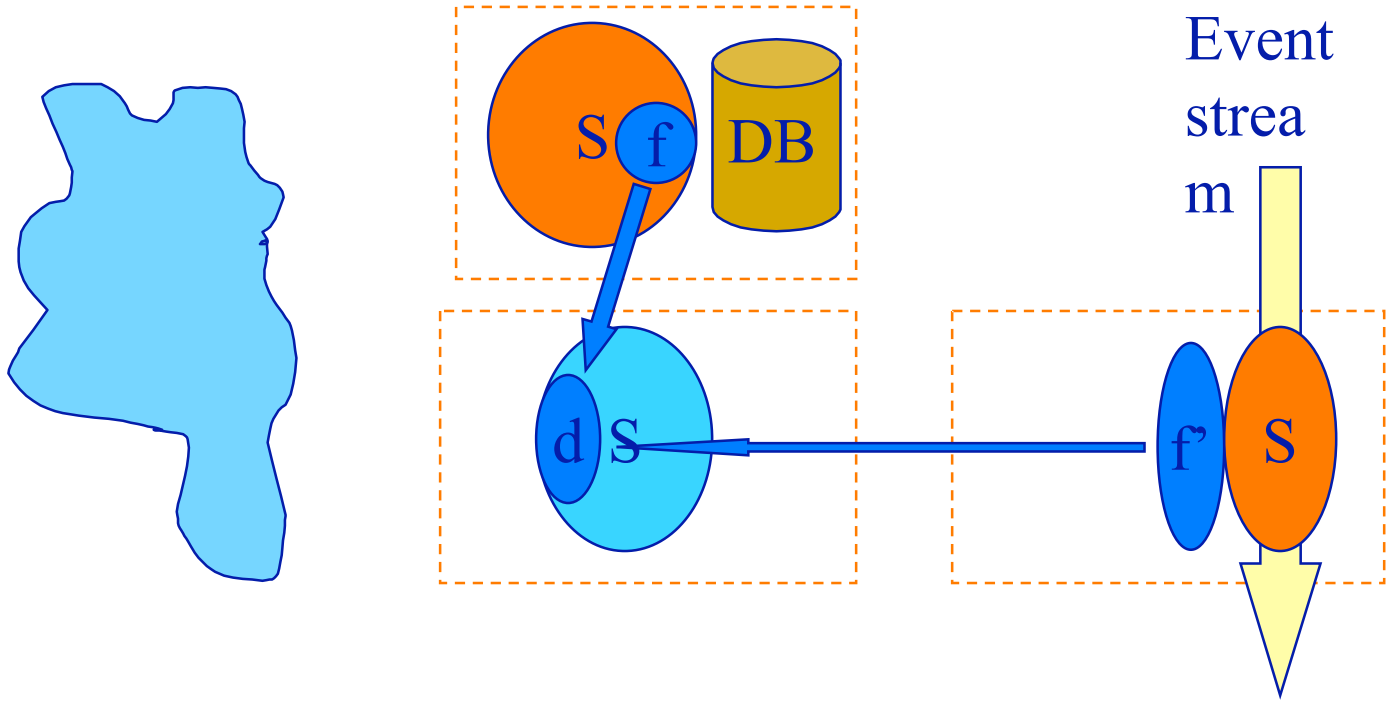
```
● subID subscribe   (waifID, taddr, params)
● subID unsubscribe (waifID, subID)
●       dispatch    (waifID, subID, event)

● Example params: { 'threshold' ='updates',
                   'datatype'  ='busroute' }

● Example event: {'weather':{ 'temp':85,
                              'wind':1.9 },
                 'busroute':{'busnr': 20,
                             'time': 08:23 }
                 }
```

3. WAIF Service Implementations

- Operational:
  - Bus route service
  - StormCast weather (http://weather.cs.uit.no)
  - Time alerts
  - Custom filter server
- In progress:
  - Concerts and events
  - RSS news feed

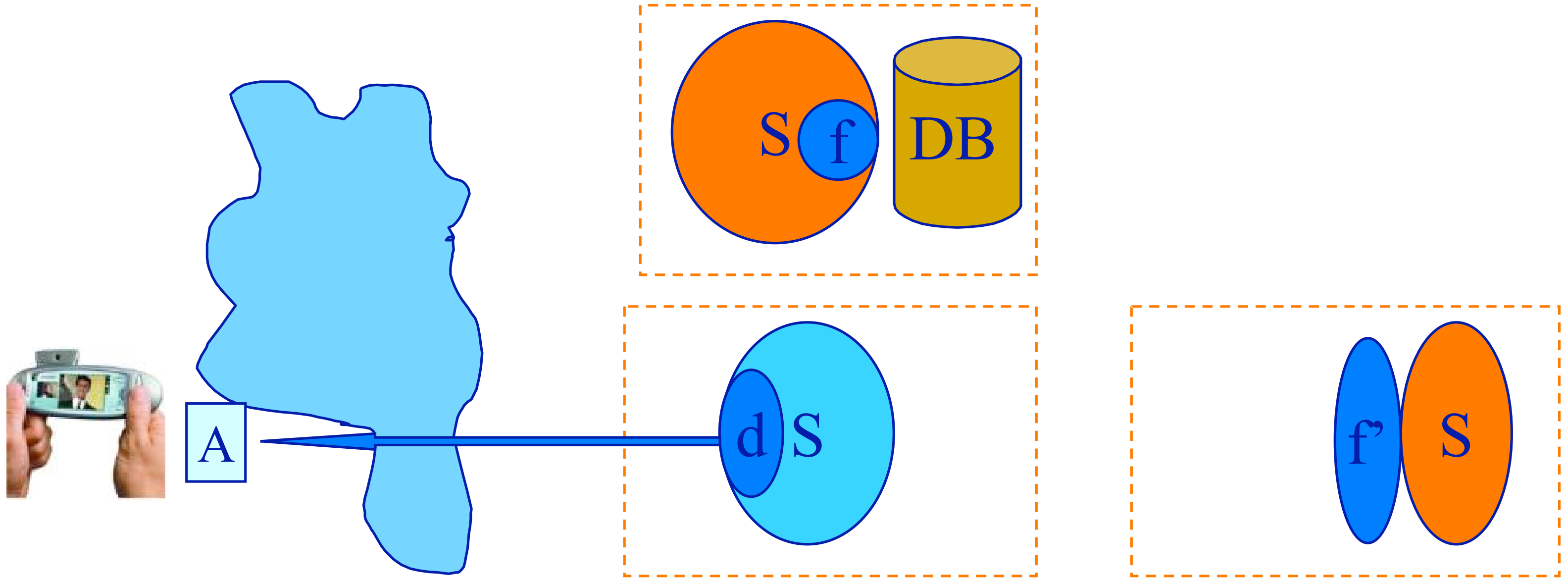
4. Lessons Learned

- Apply personalized filters on streams of real-life events.



4. Lessons Learned

- High expressiveness gives high-precision alerts.

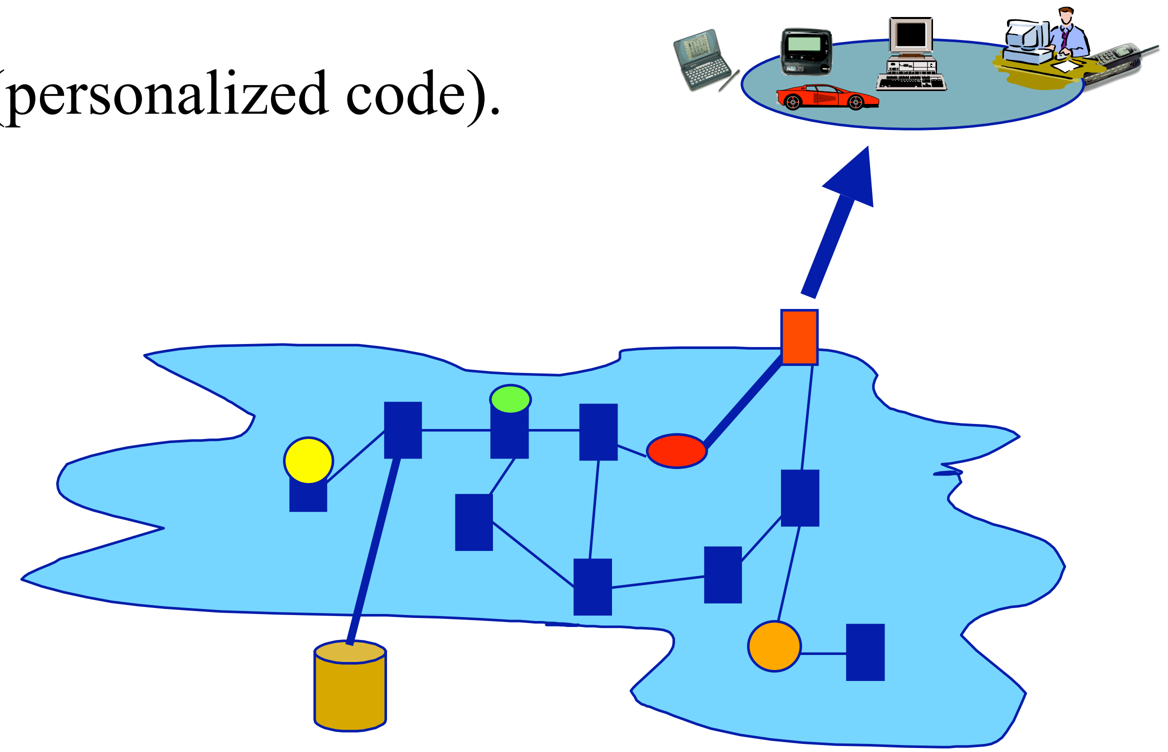


4. Related work

- Web services (Microsoft, IBM, BEA).
- Haystack and Oxygen (MIT).
- Oceanstore (Berkeley).
- Spinglass (Cornell).
- Semantic Web (W3C).
- Autonomic Computing Initiative (IBM).
- Pervasive computing, Pastry (DHT), Scribe (Microsoft Research).
- Aura (Carnegie Mellon University).
- Project JXTA (Sun)

4. Concluding Remarks

- Next generation Internet:
  - Pervasive.
  - Extensible (personalized code).
  - Push based.



http://www.waif.cs.uit.no

Questions?