System support for adaptation and composition of applications

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First, a video

Note: not intended as a product endorsement!

Question: why doesn’t any old software Just Work like this?

Getting application code talking

It's hard to get arbitrary bits of application code talking:

- different API calls
- different data structures
- different protocols
- different control structures, threading models. . .
- different language-level implementation details
  - storage management
  - threading semantics, concurrency primitives
- maybe no visible programmatic interface at all. . .

"Solutions": standards; hand-written glue; don't do it.

Mismatch is inevitable—must do *adaptation*.

Why the operating system is responsible

A problem just for the app developers? Not necessarily:

- OS has “component model”, controls communication
  - linkage / shared mem, pipes, sockets, filesystem. . .
- process/library notions are already too crude:
  - too big for precise isolation, security, accounting. . .
  - fail to capture dynamic structure below library level
    - witness research into “browser OSes”
  - would like to tackle the problem “closer to root”. . .
    - . . . meaning in the OS interfaces
  - let’s rethink linker, dyn. loader, IPC interfaces
  - simplicity, coverage, adoptability, performance. . .
- *black-box* adaptation $\rightarrow$ *interposing* on communication

Adaptation, configuration languages

Glue code is tedious, fragile, error-prone.

- e.g. regex-based string rewriting
- e.g. implicit binding by name-matching

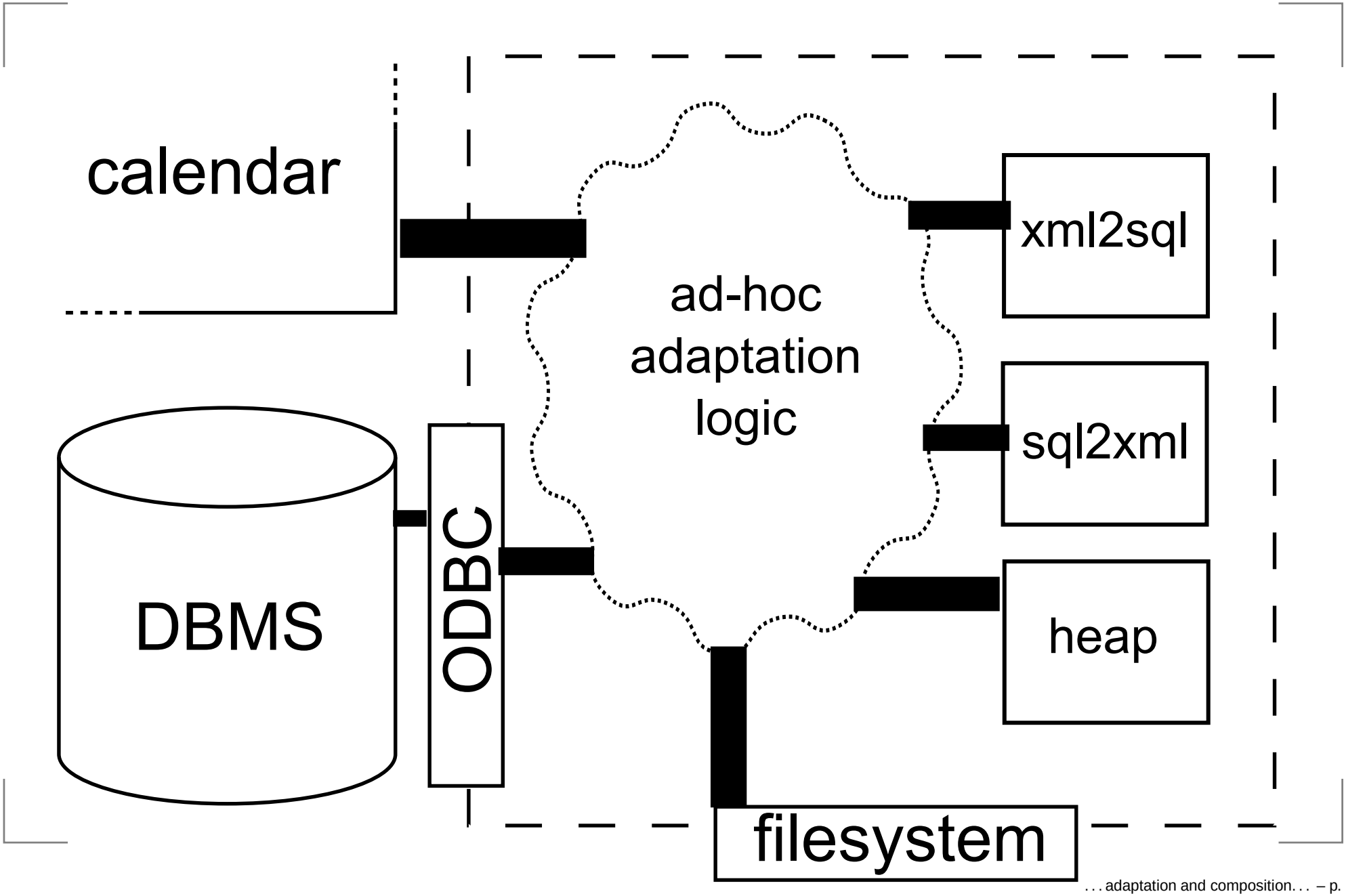
Want domain for specifying *what* and *how* of composition

- *separate* from programming languages
- explicitly captures wiring
- specialised towards *adaptation*

Goal: separation of *functionality* from *integration details*

- mix-and-match communication mechanisms
  - sockets, fs, subprocess, linkage, signals,...
- mix-and-match data encodings, protocols...

Concrete example – diagram



Concrete example – code

```
compound fsDbAdapter {
    exports [ fs_srv   {  int  open(char list,  int );  int  read(int,  byte addr, int
                          int  write(int,  byte addr, int );  void  close(int );  }  ];
    imports [ db_client  {  char  list   list  run_query(char list)  }  ];
    link  obj_elf ("C",  "fs_db_adapter.o") [  xml2sql,  sql2xml,  realfs ,  heap ]
    {     calfile   = "myCalendar.xml"; rd_qstr = "SELECT * FROM Calendar";
          wt_qstr = "INSERT INTO Calendar VALUES ";
          fs_srv <- realfs  {
               val  fd  = realfs.open ("/dev/null ",  O_RDONLY);
               val  inbuf  = heap.newbuf(sql2xml(run_query(rd_qstr)))
               val  outbuf = heap.newbuf(0)
               open( calfile ,  any mode) <- { return fd }
               read(fd,  any dest,  any len) <- { return  heap.copy(inbuf, dest,  len
               write(fd,  any buf,  any len) <- { return  outbuf.append(buf, len)  }
               close(fd)  <- { run_query(wt_qstr + xml2sql(outbuf)) }
```

What's cool

Sounds straightforward. What's cool?

- many "packagings", same abstract model
  - data representation adaptations done implicitly
- embed language into dynamic loader
  - `dlopen()` arbitrary linkage units
  - {library, file/socket} handles unified as *object handles*
  - simple in-OS object model helps language runtimes:
    - interoperability, e.g. multi-language shared heap
    - performance, e.g. avoid GC$\leftrightarrow$paging interaction
- extensible set of binary adaptation primitives
  - argument remapping; protocol adapter synthesis.
  - extend static data structures, initialisation
  - ...

Status and current work

Current work extending Knit to support. . .

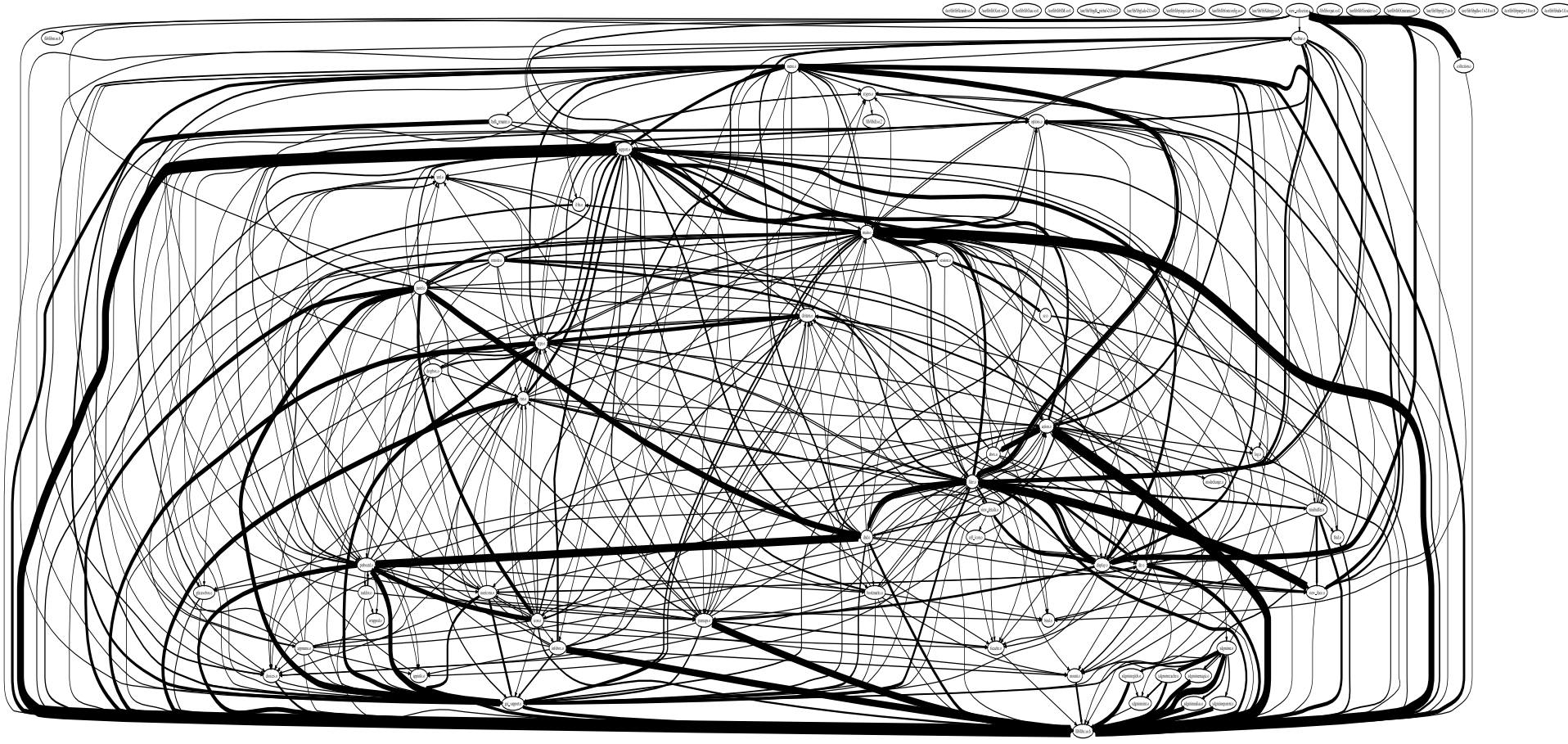
- . . . simple compositions
- couple of different languages/packagings
- e.g. share Firefox's history log with file manager

Blocked by current sideline: software visualisation

- want to identify candidate re-usable code. . .
- . . . *by inspection* – need a picture e.g. linkage graph
- too many edges! aggregate them by cluster. . .

Thanks for listening. Questions?

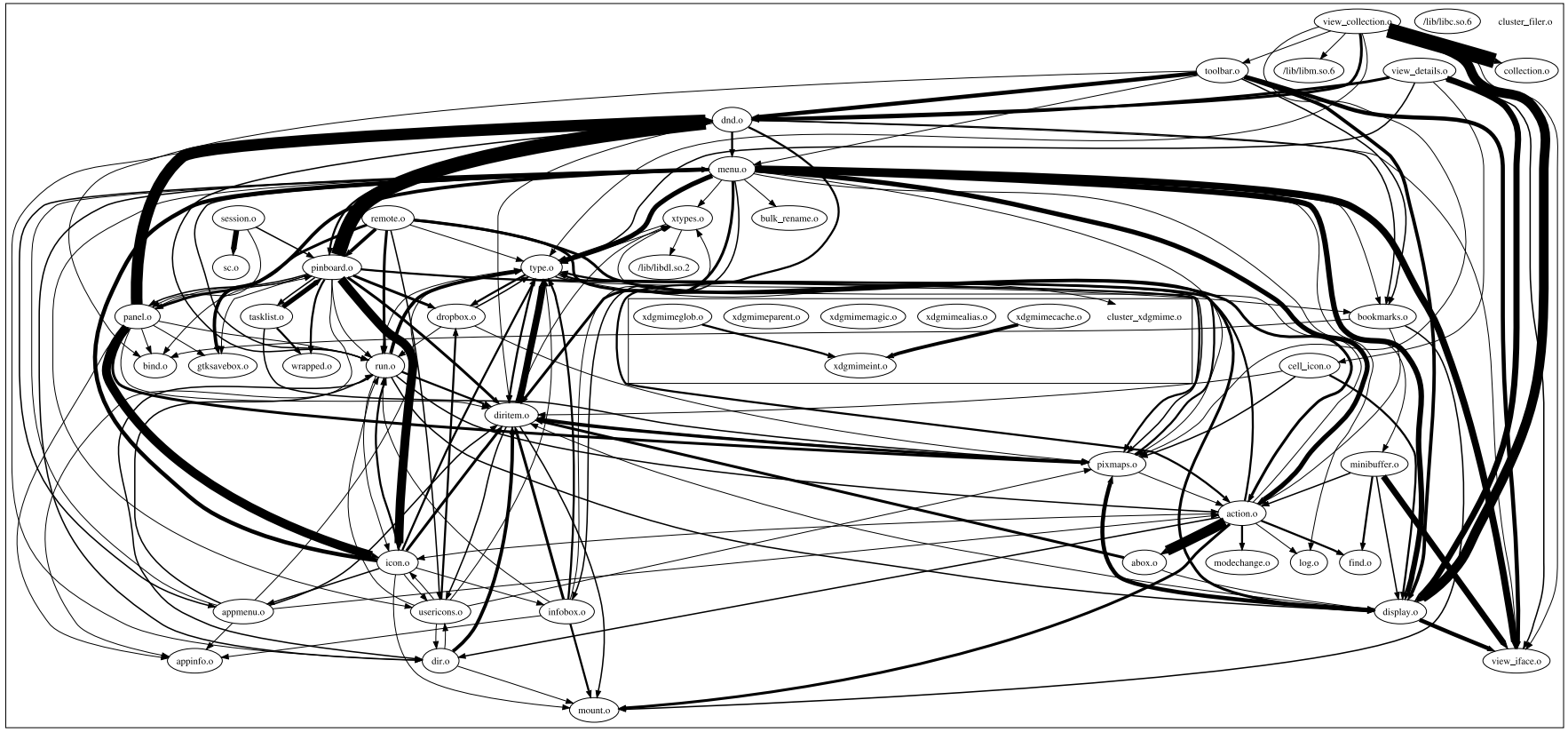
Linkage graph… (rox-filer)



Wanted: decomposed representation with fewer edges

ROX filer after some ad-hoc clustering

After four rounds of head-scratching, it looks a bit better.



This was done mostly by deleting “pervasively-connected” nodes, together with their edges.

Why it's not just. . .

- done by libraries?
  - need agreed-upon interfaces
- done by plug-in systems?
  - must conform to standard; not portable
- done by IDL compilers?
  - too specialized; fixed at compile-time
- done by component middleware?
  - little API adaptation; requires homogeneity
- done by aspect-oriented programming?
  - aspects bundle logic with interposition points
  - tend to therefore be codebase-specific
- done by web services etc.?
  - again, no API-level adaptation;

Supporting definitions

```
unit calendar {
        imports [ fs_srv { int open(char list, int);
                           int read(int, byte addr, int);
                           int write(int, byte addr, int);
                           void close(int);
        exports [ /* ... */ ];
        files { exec_elf("C", calendar) }
}
unit dbms {
        exports [ db_client { runQuery(char list) } ];
        files { obj_elf("C", odbc.o) }
}
unit xml2sql {
        exports [ xml2sql { xml2sql(char list) } ];
        files { exec_generic("execve_filter", xml2sql) }
}
```