EXPERIENCE WITH

COMPONENT-BASED DEVELOPMENT

OF A TELECOMMUNICATION SERVICE

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1 This is a significant example of CBSE.

2 This is not object-oriented programming.

3 The component architecture works really well.

4 The component architecture is starting to become influential.

AT&T CALLVANTAGE[SM] SERVICE

IS A SIGNIFICANT EXAMPLE OF CBSE

- It is a consumer, broadband, voice-over-Internet-Protocol (VoIP) service.
- We built, deployed, and extended the advanced features using component-based technology.
- We support many thousands of customers nationwide.
- The service has won two industry awards, citing its voice quality and advanced features.

WHAT DOES CALLVANTAGE DO?

Here are the commercials made by Oscar-winning documentary director Errol Morris, and starring three of the co-authors of this paper.

[play DVD]

This is not object-oriented programming.

DISTRIBUTED FEATURE COMPOSITION (DFC)

. . . is an architecture for telecommunication services, designed with the goals of:

- feature modularity
- structured feature composition
- management of feature interactions

. . . is an adaptation of the *pipes-and-filters* architecture to the domain of telecommunications.

The architecture is implemented with object-oriented programming, so it is a higher-level, more domain-specific abstraction.

DISTRIBUTED FEATURE COMPOSITION (DFC)

a box/component is a concurrent process, implements a feature

connectors between components are "little telephone calls"

unbounded queues are necessary for signaling (rather than some more synchronous connector) because new stimuli can come from either end or the middle

MODULARITY IN A PIPES-AND-FILTERS ARCHITECTURE:

optionality: **every box is optional**

autonomy: **whenever a box has a function to perform, it can perform it without help**

transparency: **whenever a box has no function to perform, it is unobservable**

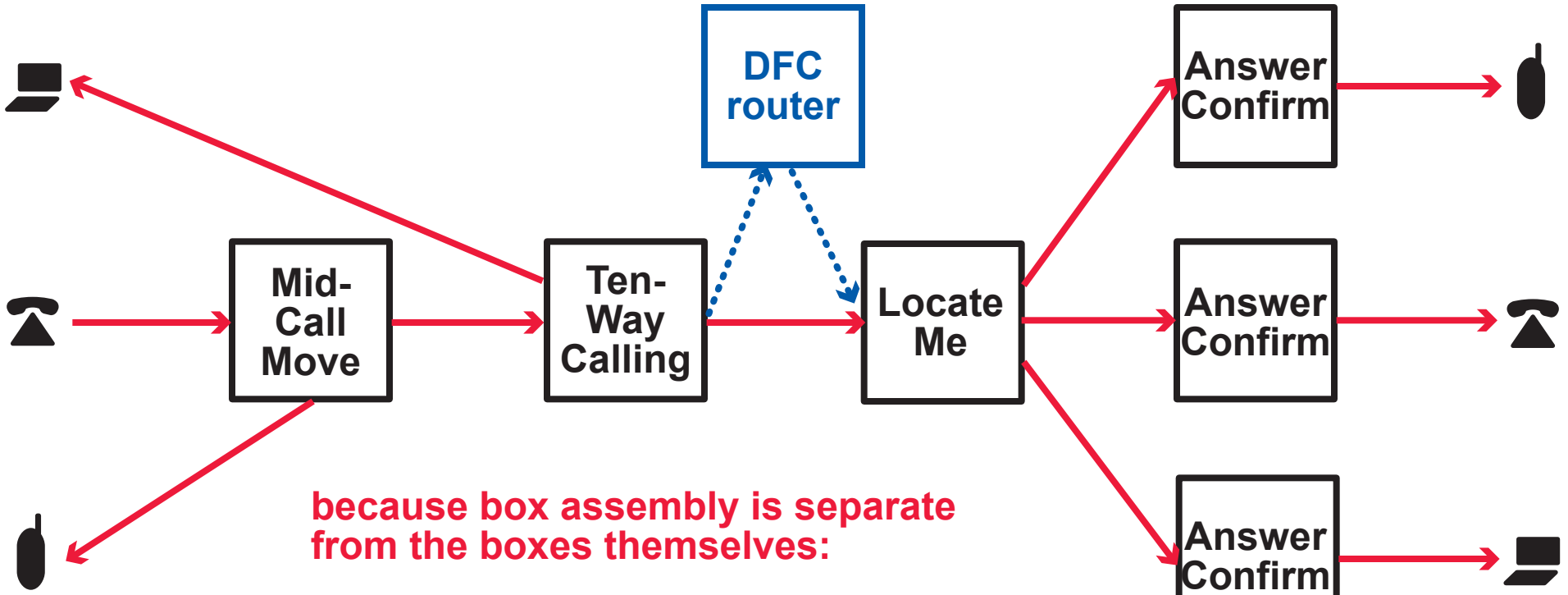
context-independence: **a box does not know or need to know what is at the other end of its calls**

DISTRIBUTED FEATURE COMPOSITION (DFC)

the graph of boxes and calls is assembled dynamically and evolves over time

a box can affect assembly by making highly constrained changes to setup signals

the assembly mechanism is the DFC router, which chooses a box based on source and target addresses, feature subscriptions, feature precedences, and history carried in the setup signal



because box assembly is separate from the boxes themselves:

- boxes know nothing about other boxes
- the assembly mechanism is powerful and well-suited to telecommunications

USE OF COMPONENTS

A typical call between two subscribers would have something like 20 feature boxes.

BOXES ARE IDENTIFIED FEATURES

15 identified and named features of the service are implemented by feature box classes.

The default situation is one feature box class per feature.

BOXES ARE REUSABLE BUILDING BLOCKS

There is reuse at several levels:

- **reuse of features from previous services**
- **reuse of generic box classes as components of complex features**
- **reuse of parameterized programs to make new box classes**

BOXES ARE ADAPTORS

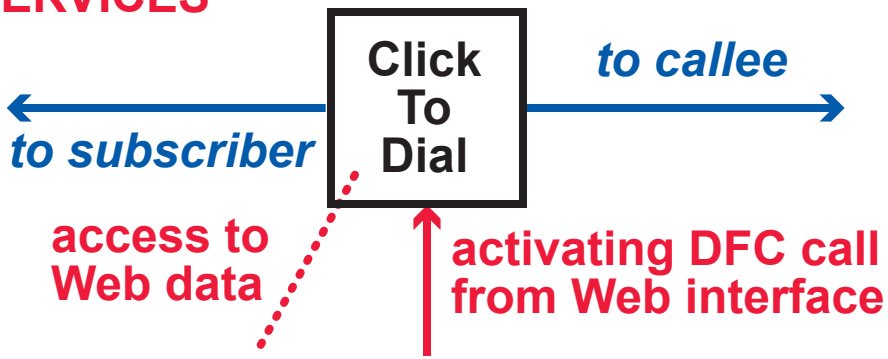
The DFC-based application server operates in an environment with many other hardware components such as VoIP switches, gateways, routers, telephone adaptors, and media servers.

All VoIP technology is immature.

We use boxes as adaptors to solve integration problems and make up for deficiencies in other components.

Modularity is especially important here —these are decisions we want to back out of, not embed deeply in code.

BOXES ARE INTERFACES TO WEB SERVICES



The component architecture works really well.

EXPERIENCE WITH THE COMPONENT ARCHITECTURE

DEVELOPMENT SPEED

We delivered 11 complex features . . .

e.g., Mid-Call Move
Ten-Way Calling
Parallel Find Me
Voice Mail

. . . in 2 months from inception of the project.

all indications are that this speed is unprecedented

SOFTWARE QUALITY

We analyzed and managed feature interactions during the design process, concurrently with requirements definition and coding.

There have been very few bugs in feature code.

MAINTAINABILITY

Features in subsequent releases (with feature expansion and contraction) have been easy.

Most maintenance issues are integration problems—because of immature VoIP technology—and they arise frequently.

PERFORMANCE

We have struggled throughout the project to improve the performance of our (research prototype) software.

It is now comparable to the performance of other alternatives.

most important, we are reaching a point where the performance penalty due to modularity is negligible

The component architecture is starting to become influential.

INDUSTRY STANDARDS

OUR PROBLEM

From an industry perspective (including the perspective of AT&T), DFC is a radical and unpopular technology, because we dare to put . . .

- modularity
- compositionality

above . . .

- performance
- using industry standards

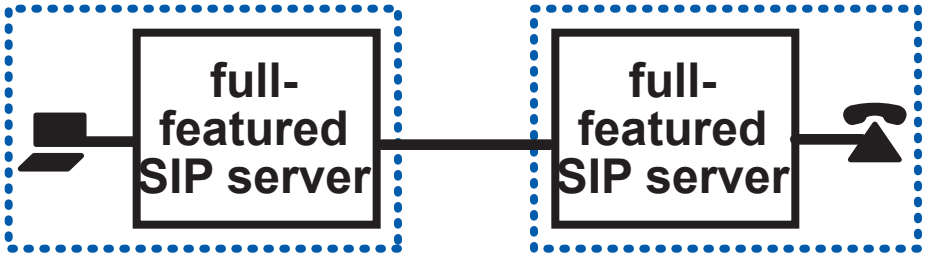
The Session Initiation Protocol (SIP) is the dominant VoIP standard.

OUR SOLUTION

We can now run DFC inside a standardized SIP Servlet Container, which makes AT&T happier.

We have vendor support for a next-generation SIP Servlet standard incorporating DFC principles.

Current SIP technology cannot support this configuration:



We can—maybe when people realize the limitations, there will be more respect for compositionality.