PART FOUR:  
THE SIGNALING VIEW  
OF CONNECTION SERVICES

this lecture is centered on DFC, 
and explains many of its principles
**DISTRIBUTED FEATURE COMPOSITION (DFC)**

*usage:* a dynamically assembled graph of boxes and internal calls

*box:* a concurrent process, providing either interface or feature functions

*internal call:* a featureless, point-to-point connection with a two-way signaling channel and any number of media channels

*persistent data:* usually partitioned by feature, interface to Web services

**FEATURE INTERACTION (COMPONENT COORDINATION) MECHANISMS:**

- Two-way signaling along paths consisting of internal calls and intra-box *links*
- The routing algorithm supports abstract addresses, feature precedence, forks and joins

**THE MODULARITY MECHANISM IS PIPES AND FILTERS:**

- Each box has transparency, autonomy, and context-independence—it does not know or need to know which other boxes are present
DFC ROUTING (VERSION 2)

transparency: a feature box can continue the chain of calls without changing any address

autonomy: a feature box can change an address and thereby alter the routing

context independence: no feature box knows or sees the name of any other feature box
THE PROTOCOL FOR DFC INTERNAL CALLS (VERSION 1)

a two-way FIFO signaling channel exists; boxes can send status signals to each other

either port can initiate teardown

an internal call always succeeds

status signals *avail*, *unavail*, and *unknown* usually travel from callee port to caller port

if a port receives a status signal after sending a teardown, the status signal is ignored
**SIGNALING INTERACTIONS**

*transparency:* a box behaves transparently when its functions are not needed

*autonomy:* each box has the power it needs to perform its functions independently

- **target zone**
  - IVR dialogue with caller; caller chooses whether to interrupt targeted subscriber
  - if no, QT sends *unavail* upstream
  - IVR dialogue with caller; caller records voice mail in subscriber's mailbox
  - if whole attempt times out, send *unavail* upstream
  - if single branch succeeds, send *avail* upstream

- **QT**
  - if yes, QT continues the chain and becomes transparent

- **PR**
  - absorb failures of single branches

*context independence:* by its behavior and its place in the precedence order, a feature box can trigger, delay, or cancel other features without knowing whether they are present or what they are
TWO INTERESTING FEATURES

**MID-CALL MOVE**
- Move to cellphone
- Call
- Answer
- The two people can talk throughout the move
- Move is complete when user hangs up original phone

**CALL WAITING**
- Call
- Ringback
- User can now switch back and forth between the two parties
it is relatively easy to add each feature by modifying the base description, but what is the composition of all three?

each modified machine has states and events not found in the other

there is more than one "correct" composition
**BASE DESCRIPTION**
(Featureless service) is the architecture itself.

Free and reversible: different instances appear in both source and target zones.

Bound and reversible: the same instance appears in source and target zones.

**MID-CALL MOVE**

- **IB subs** 
  - src = subs 
  - trg = far

- **MCM subs** 
  - src = subs 
  - trg = far

- **IB new** 
  - src = far 
  - trg = new

**CALL WAITING**

- **IB subs** 
  - src = subs

- **CW subs** 
  - src = subs 
  - trg = subs

- **talking** 
  - ? receive_new
  - ? disc_held
  - ? switch

- **talking, ringback** 
  - ? switch

- **talking, placed** 
  - ? move / ! place_new
  - ? new_failed, ? cancel_move / ! end_new
TWO DIFFERENT COMPOSITIONS OF THE FEATURES
(GENERATED BY DIFFERENT PRECEDENCE ORDERS)

a move applies to both far parties

a move applies to only one party—the one currently selected

in either composition, the features operate with complete independence
(neither even knows about the existence of the other)
THE DFC PROTOCOL (VERSION 2)

the two-way signaling channel of a call has many tunnels

tunnel 0 carries call-level status signals such as avail and unavail

each other tunnel, if used, carries the control signals for a media channel

a call can contain any number of media channels, of any media (voice, text, video, music)

a media channel can be opened from either direction, at any time during the call, and closed at any time during the call

THE POTS PROTOCOL COMBINES THE CONCEPTS OF A CALL AND OF ONE VOICE CHANNEL

TO ACCOMMODATE MULTIMEDIA SERVICES, WE MUST SEPARATE THE TWO CONCEPTS

setup

upack

open

oack

wait

ringing

ringback

avail

answered

accept

talking
A BAD FEATURE INTERACTION:
VOICE/PERSON CONFUSION

Alice has a personal address A with a Locate Me feature

Alice will participate in a voice conference at 2 p.m.

Alice asks to be called at A

Locate Me begins to search for Alice

"please wait while I locate Alice for you"

Locate Me plays music

the call is answered (but not by a person)

"your voice conference is in progress. Please enter your PIN"

"your voice conference is in progress. Please enter your PIN"

Conference Server disconnects
**THE SOLUTION IS THE RIGHT SIGNALS AND CORRECT USE OF THEM**

Alice has a personal address with a Find Me feature

Alice will participate in a voice conference at 2 p.m.

Alice asks to be called at

Conference Server

Find Me

call to a phone that Alice might answer

"please wait while I locate Alice for you", music

Alice answers

signal accept means that a voice channel is open

signal avail means that Alice is present

"your voice conference is in progress. Please enter your PIN"
A BAD FEATURE INTERACTION: LOST SIGNALS

VolP phone does its own tone generation

Bob's phone ignores ringback signal, because it is coming "too late" and "in the wrong direction"

Alice calls Bob, who has Add Callers

Bob attempts to add Carol to the conversation

Bob thinks Add Callers is not working, aborts the attempt to add Carol
THE SOLUTION TO LOST SIGNALS

Bob's phone is supposed to perform the tone generation, but ignores the ringback signal, because it is coming "too late" and "in the wrong direction".

Bob attempts to add Carol to the conversation.

A feature box generates the right tone in this and other similar situations.

DFC does not restrict the number or direction of status signals, at the call or media levels, because features use status signals in a wide variety of ways.
FEATURES, REVISITED

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DVC SUPPORTS MODULARITY FOR A VERY WIDE RANGE OF FEATURES

DFC IS BY FAR THE MOST SUCCESSFUL MEANS TO FEATURE MODULARITY IN TELECOMMUNICATIONS

many other approaches have been tried

AN INEVITABLE BY-PRODUCT OF FEATURE MODULARITY IS FEATURE INTERACTION
to manage interactions:

- diagnose possible interactions
- decide which are desirable and which are undesirable
- prevent the bad interactions, enable the good interactions
HOW DO FEATURES INTERACT IN DFC?

ROUTING

identification: features affect the identification information that other features receive

contact: features affect the contact addresses that other features receive

invocation: features affect which other features are invoked

SHARED SIGNALS

a feature can trigger, delay, or suppress the functioning of another feature

the presence of a feature can cause signals to be interleaved, iterated, or reversed with respect to the ordinary features of a single call; this affects other features that are sensitive to them

DATA (this is unexplored territory)

MEDIA CHANNELS

features manipulate the same media channels

this taxonomy is pragmatic and intuitive rather than formal; it is evolving