Imperial College London

Session Types and their Applications

Code Mesh November 5th/6th 2020 Nobuko Yoshida

Session types serve as both **theoretical** and **engineering foundations** of **communication-centred programming languages and systems** and **software**, so that the society can use **safe** **concurrent systems** and **distributed services.**

Communications are Ubiquitous

- Increasingly, **communications** are the way to organise software and systems.
- Industry trend – programming languages with **explicit message-passing primitives.**

microservices






Problems: Ambiguity

- Protocol descriptions are **ambiguous**
- **SMTP: simple mail transfer protocol**
  - They are written in English, often very long

RFC 821 August 1982
Simple Mail Transfer Protocol

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3.1.  MAIL

   There are three steps to SMTP mail transactions.  The transaction
   is started with a MAIL command which gives the sender
   identification.  A series of one or more RCPT commands follows
   giving the receiver information.  Then a DATA command gives the
   mail data.  And finally, the end of mail data indicator confirms
   the transaction.

      The first step in the procedure is the MAIL command.  The
      <reverse-path> contains the source mailbox.

         MAIL <SP> FROM:<reverse-path> <CRLF>

      This command tells the SMTP-receiver that a new mail
      transaction is starting and to reset all its state tables and
      buffers, including any recipients or mail data.  It gives the
      reverse-path which can be used to report errors.  If accepted,
      the receiver-SMTP returns a 250 OK reply.

      The <reverse-path> can contain more than just a mailbox.  The
      <reverse-path> is a reverse source routing list of hosts and
      source mailbox.  The first host in the <reverse-path> should be
      the host sending this command.

      The second step in the procedure is the RCPT command.

         RCPT <SP> TO:<forward-path> <CRLF>

      This command gives a forward-path identifying one recipient.
      If accepted, the receiver-SMTP returns a 250 OK reply, and
      stores the forward-path.  If the recipient is unknown the
      receiver-SMTP returns a 550 Failure reply.  This second step of
      the procedure can be repeated any number of times.
```

Problems: Concurrency Bugs

- Communications increase **concurrency bugs**
  - Survey of 4K users [golang.org]
  - Analysis of 6 large software systems [ASPLOS 19]

deadlock

channel errors

More than a half of concurrency bugs in Go are caused by communications.

The Go Gopher

Problems: Concurrency Bugs

- Communications increase **concurrency bugs**
  - Survey of 4k users **[golang.org]**
  - Analysis of 6 large software systems **[ASPLOS 19]**

More than a half of concurrency bugs in Go are caused by communications.

Session Types

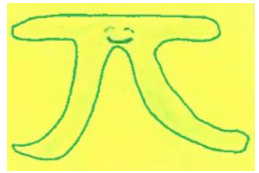
- Prevent concurrency bugs.
- Can abstract, implement and manage communications as **Protocols.**
- **Clean, Cheap** and **Retrofittable.**

Why Session Types, Why Now?

Significant academic and industry interests via fundamental breakthroughs

Milner, Honda, NY

Binary Session Types — ESOP'98



Joined W3C Standardization — 2002

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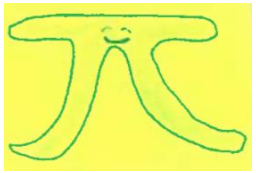

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Multiparty Session Types — POPL' 08

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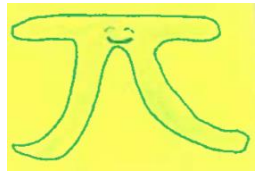

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largest open source company in the world

Red Hat

Scribble

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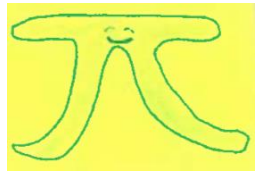

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Multiparty Session Types — POPL' 08

25M US$ large cyber infrastructures

OCEAN OBSERVATORIES INITIATIVE

Red Hat

Scribble

middleware standardisations

AMQP Advanced Message Queuing Protocol

RabbitMQ Messaging that just works

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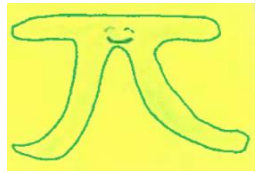

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ETAPS Test Time Award 2019

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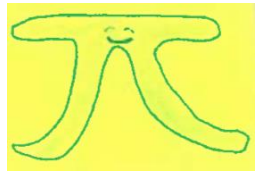

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POPL Influential Paper Award 2018

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ETAPS Test Time Award 2019

PLDI'19, ICSE'18, CC'18, CAV'19
POPL'19, POPL'19, POPL'19,
ECOOP'19, ESOP'19, ESOP'18
CONCUR'19, FOSSACS'19,
LICS'18, FOSSACS'18

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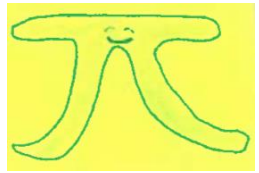

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