

University of Applied Sciences



Process Algebra in HATA • 2

The formal theory driving HATA specifications - Parallel Processes

Intro

HATA can be used to specify sequential behaviour, but its full potential lies in specifying parallel behaviour including communication between separate processes.

Communication

Parallel processes do not operate in a vacuum, but need to be able to exchange information. In HATA communication is implemented so-called communication action in the definition of process CoinSystem:

comm action payment(Coin)

Sequential processes are specified using two basic operators: the sequential composition specifying a certain order of events, e.g. *a*; *b* and the alternative composition specifying a choice between alternatives, e.g. *a* | *b*.

Parallel Composition

The parallel composition expresses the fact that two possible continuation paths have to be executed in parallel. One can express that the process term x and the process term y are happening at the same time as follows: x & y. A vending machine with two separate coin slots and two independent entities that can serve tea and coffee simultaneously can be defined as follows:

insert(coin10c); tea() & insert(coin25c); coffee()

The corresponding transition system allows for the individual actions of both process terms to be merged in every possible way as long as the order of these actions as defined by the sequential operator is respected. through multiple actions with the same signature happening at the same time. Information can be exchanged during communication through the data parameters of an action. A variable can be used as a data parameter and as a result of the communication this variable will be instantiated with a specific value, if the communication partner offers a value for the given parameter.

The following example shows two parallel processes that communicate through the action payment.

CoinBox=
payment(Coin c); CoinBox

Customer=
payment(coin10c);
payment(coin25)

CoinSystem =

Example: A vending machine

Below is an example of a specification of a vending machine that sells coffee for 25 cents and tea for 10 cents. To show an example of communication in HATA, two customers will interact with the machine.

This example assumes the existence of a data type Drink containing at least coffee and tea as representatives and a data type Coin containing at least coin10c and coin25c. Moreover, the existence of a mapping from Drink to Coin called cost is assumed.

public process VendingMachineWithCustomers {

// --- Behaviour definitions of processes

comm action button(Drink d); comm action drink(Drink d); comm action payment(Coin c);



Customer & CoinBox

The intended transition system is as follows:



However, because of the rules of the parallel composition, the *payment* action can occur in each process separately without the need to wait for a corresponding action to occur in the other process.

To ensure that certain actions can only occur as part of a communication the *comm* modifier keyword is used. To achieve the intended behaviour, action *payment* has to declared to be a // "main" process and entry point

```
public VendingMachineWithCustomers() {
    VendingMachine()
    & CoffeeCustomer()
    & TeaCustomer();
}
```

// auxiliary processes

VendingMachine() {
 button(Drink d);
 payment(cost(d));
 drink(d);
 VendingMachine()

```
CoffeeCustomer() {
    button(coffee);
    payment(coin25c);
    drink(coffee)
}
```

TeaCustomer() {
 button(tea);
 payment(coin10c);
 drink(tea)

Process Algebra vs. Programming Languages Process algebras traditionally use a different notation for the process operators than the one used in HATA. The parallel composition is traditionally written as: "||". In HATA the alternative operator is written as "|", a disjunction. Therefore, the logical consequence is to use "&", a conjunction, for the parallel operator. The use of "&" meaning "and" is also common in boolean expressions.

Conclusions

The parallel operator "&" has been introduced above as the basic way to express concurrency in HATA. The communication and exchange of information between processes through the use of actions with an equal signature has been shown. Finally, a somewhat larger example of a simple vending machine in interaction with two separate customers, illustrates the use of the parallel composition and the use of communication to exchange information between different processes.

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