Abstract

This PhD dissertation develops a formal model and theory for reasoning about mobile and distributed systems. In particular, we consider systems consisting of mobile computing devices containing mobile computations, where both kinds of entities can move between locations and where the entities can contain local information.

We begin by presenting a process calculus that focus on the following key concepts: linear and non-linear process-passing; named, nested locations; and local names. These concepts are well-known and well-understood in the 'concurrency and mobility' community, but the combination of them proposes new challenges. In particular, the scope extension across location boundaries requires special care. We call the process calculus Higher-Order Mobile Embedded Resources and abbreviate it Homer.

We examine the expressive power of Homer and whether name-passing can be a derived notion in Homer by giving an encoding of the synchronous π-calculus in Homer. The encoding establishes that process-passing together with mobile resources in, possibly local, named locations are sufficient to express π-calculus name-passing.

We provide Homer with a type system for distinguishing between (affine) linear and non-linear higher-order mobile processes by assigning types to locations, names, and variables. The type system is inspired by the linear λ-calculus and by ideas from reference types. We investigate the behavioural theory of Homer by equipping the calculus with behavioural congruences defined on top of the reaction semantics through the usage of barbs. We then proceed to provide the behavioural congruences with sound and complete coinductive characterisations using labelled context bisimulations. We thereby provide the first sound and complete characterisation of a behavioural congruence for a calculus combining non-linear and linear process-passing. We utilise the method of Howe to prove that labelled context bisimulations are congruences. As a technical contribution we apply the bisimulation to prove that scope extension across linear location boundaries is sound.

The meta-model of bigraphical reactive systems has been proposed by Milner as a unifying meta-model for representing process calculi for concurrency and mobility. We evaluate the applicability of bigraphical reactive systems by giving a bigraphical semantics of Homer. The presentation of Homer as a bigraphical reactive system again highlights the issues with scope extension across location boundaries and the locality of a name. The presentation requires that we refine the definition of parametric reaction rules to keep explicit track of the locality of names.

We end the dissertation with an investigation of the connection between type systems for process calculi and sortings for bigraphical reactive systems. Concretely, we examine an encoding of a typed π-calculus in a sorted bigraphical reactive system. Using the theory of bigraphical reactive systems we obtain a coinductive characterisation of a behavioural congruence for the calculus.