

# PhD Project-Plan

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This document gives detailed information about the structuring of the research undertaken in this PhD.

## 1 Years

The whole PhD lasts for 3 years, 36 Months, from October 2016 to September 2019 and thus I will structure it according to 3 years where each year will be a major milestone - which is also intended by the Computer School.

### 1.1 1st Year: Groundwork

In this year I will learn basics and develop and research the methodology I will use for the main work in the 2nd year. Also I want to write a paper about this work and try to publish it on a Conference or Journal. The time-frame will be set by the date of the 1st year annual oral report which will happen beginning of July thus there are about 6 Months time (counting including January '17 and leaving out July '17). These are the things I want / need to achieve this year:

- Prototyping in Haskell, Scala and Java
- Study Actor-Model theory: Hewitt, Greif, Clinger, Agha
- Get into reasoning about programs
- Basics of Economics [2], [3]
- Basics of ACE: Tesfatsion
- Implement PureAgents Library
- Write & publish paper
- Write 1st year report
- Prototype ACE using Akka and Haskell

Important and mile-stones:

April / May	Finished and submit Paper
June (Mid)	Finished writing 1st year report
July	Oral annual report

### 1.1.1 January

#### Research

- investigate and increase low performance of Haskell implementations
- implement environment-access in SEQ & PAR of Haskell
- implement concurrent semantic in Haskell

#### Paper

- Rework abstract
- 30min presentation of content

#### Reading

- Book "Gleichzeitige Ungleichzeitigkeiten"
- Complex Systems Stuff
- Find semantics of simulation papers

### 1.1.2 February

#### Research

- Embed SEQ & PAR in Yampa
- Experimenting

**Paper** Write first very basic draft

#### Reading

- Re-Read existing papers on functional programming and simulations
- Semantics of simulation papers

### 1.1.3 March

#### Research

- Implement SimTime Actors in Akka: have global simulation-time instead of local real-time
- Reasoning about Haskell-Implementations
- Continue Experimenting

**Reading**

- Read Semantics of Actors (Greif & Clinger)
- Semantics of simulation papers

**Paper** Write second refined draft

**1.1.4 April****Research**

- No programming: code-freeze
- continue experimenting

**Paper** Do refinements until final version

**Reading**

- Continue reading Semantics of Actors (Greif & Clinger)
- Semantics of simulation papers

**1.1.5 May**

**Paper** Submit to selected Conference/Journal (may also be at the end of April)

**Reading** Read papers not read so far but include in 1st year report

**Writing** Start writing 1st year report

**1.1.6 June**

**Research** Do 1st Year oral exam

**Reading** Read papers not read so far but include in 1st year report

**Writing** Finalize 1st year report

**1.1.7 July to September****Research**

- Prototyping ACE using my Haskell-Library and Akka: bilateral trading, EDSL for ACE and qualitative modelling, reasoning in ACE

## Reading

- ACE basics papers (Tsfatsion)
- ACE models for trading/bartering (e.g. Gintis)

### 1.1.8 October

2nd year starts

## 1.2 2nd Year: Main Work

Applying 1st year results, methods and experiences to develop and write main paper to be published in a journal in 3rd year thus in 2nd year the main work and implementation will be done. The idea is to start from Ionescus Framework [?] and build on his paper.

- Implement Ionescus framework using the methodology developed in 1st year
- Generalize implementation to market models
- Learn Agda and dependent types
- Dig deeper into equilibrium theory
- Get into market-microstructure: [?], [1]
- Dig into *emergent properties* of systems. Can they be formalized?
- Get into basics of Category-Theory [?] [4]
- Get into basics of Type-Theory (found good lectures on Youtube)

## 1.3 3rd Year: Finalizing, Publishing & Writing

I plan to be finished - or nearly finished - at the end of the 3rd year. In this year I will finalize the work of the 2nd year, publish the my main journal paper (and optional fun-papers if possible) and will write down the thesis.

To have a bit of distraction and to prevent myself to become too locked in in writing on the thesis I will also work on my optional fun-papers (see below) and hope to at least finish them and maybe publish them - at least I want to present them to 2-3 audiences (e.g. FP Lunch) to test the reaction (especially the Genesis-Paper).

- Finalize research of 2nd year
- Publish journal paper
- Write thesis
- Work on fun-papers

## 2 Papers

This is the list of papers I have in my mind and includes both work mandatory for the PhD and optional ones. The latter ones are just fun/philosophical-papers, not directly related to my PhD but somehow tangential with the very basic direction - they are intended to be worked on in my free-time and to free my head when wrestling too hard with my PhDs main work.

### 2.1 Influence of Simulation-Semantics on Dynamics of Agent-Based Simulations.

**Type:** Groundwork

**Target:** Conference/Journal

**Requirement:** Mandatory

The first paper which describes how one can implement ABM/S in Haskell and compares the implementation and results to Java and Akka. A major focus are update-strategies, parallelism, reproducibility, reasoning and comparability between the various implementations. Actors: The Future in Agent-Based Simulation & Modelling? Although the actor-model is quite old (beginning of the 70s) it seems to have a revival both in Erlang in the 90s and now in the Framework Akka (based on Scala). It is one way of organizing highly parallel (and optionally distributed) applications. Also the actor-model is very close to the agent-metaphor where the latter one was strongly inspired by the former one. Thus It would be very interesting to look closer into how the Actor-Model can be utilized to ABM/S as it seems that this has not been properly done yet. This paper will establish my methodology in using Haskell / pure functional programming in the 2nd year main work.

### 2.2 Pure Functional ACE (Catchy title yet to be defined)

**Type:** Main PhD Work

**Target:** Journal

**Requirement:** Mandatory

Is the main work of the PhD and targeted at publication in a Journal. The exact topic and content will be clarified at the beginning of the 2nd year. Mainly it will describe how to implement Ionescus Framework of Gintis trading model and extend it to a more general Market-Model. It will also give an outlook on implementing it using dependent types.

### 2.3 Pure by Nature: A Library for pure Agent-Based Simulation & Modelling in Haskell

**Type:** Extension

**Target:** Conference

**Requirement:** Optional

This paper describes the ideas and theory behind the implementation of my ABM/S library "PureAgents" in Haskell.

## **2.4 Time in Games: a Tron Light-Cycle Game in Dunai**

**Type:** Fun

**Target:** Conference

**Requirement:** Optional

This paper describes the 2D light-cycle game inspired by the movie Tron implemented in Dunai. It allows to turn back time.

## **2.5 Pure Functional Islamic Design**

**Type:** Fun

**Target:** Conference

**Requirement:** Optional

Inspired by the paper "Functional Geometry" by Peter Henderson I had the idea to come up with a EDSL for declaratively describing pictures of islamic design which are then rendered using the gloss-library. From its focus totally unrelated to the PhD topic but still a great opportunity to learn Haskell, to learn to think functional, to learn to design my own EDSL - thus it may be a great paper to pursue even if I won't finish or produce something publishable.

## **2.6 The Genesis According to Computer-Science: Reality as Simulation of Free Will**

**Type:** Philosophy

**Target:** ?

**Requirement:** Optional

I've always been interested in a deeper meaning behind things so I want to look into the philosophy and future of simulation: why do we simulate, what can we derive from simulations, what does it say that we humans simulate, what will the future of simulation be?

I claim that our ability to "simulate" in our mind separates our intelligence from those of the animals and that this is a unique property of humans. Also i think the future of simulation will be that humankind will do its own creation/live (artificial life, conciousness) which allows to accurately simulate a given setting - this of course could have ethical implications.

## References

- [1] BAKER, H. K., KIYMAZ, H., ALAN, N. S., BILDIK, R., AND SCHWARTZ, R. Market Microstructure in Emerging and Developed Markets. *Business Faculty Book Gallery* (Jan. 2013).
- [2] BOWLES, S., EDWARDS, R., AND ROOSEVELT, F. *Understanding Capitalism: Competition, Command, and Change*, 3 edition ed. Oxford University Press, New York, Mar. 2005.
- [3] KIRMAN, A. *Complex Economics: Individual and Collective Rationality*. Routledge, London ; New York, NY, July 2010.
- [4] SPIVAK, D. I. *Category Theory for the Sciences*, 1 ed. Mit Press Ltd, Cambridge, Massachusetts, Nov. 2014.