Akademia Górniczo-Hutnicza im. Stanisława Staszica w Krakowie

WYDZIAŁ ELEKTROTECHNIKI, AUTOMATYKI, INFORMATYKI I INŻYNIERII BIOMEDYCZNEJ

KATEDRA INFORMATYKI STOSOWANEJ

Praca dyplomowa magisterska

Projekt języka programowania wspierającego przetwarzanie rozproszone na platformach heterogenicznych.

Design of a programming language with support for distributed computing on heterogenous platforms.

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Oświadczam, świadomy odpowiedzialności karnej za poświadczenie nieprawdy, że niniejszą pracę dyplomową wykonałem osobiście i samodzielnie, i nie korzystałem ze źródeł innych niż wymienione w pracy.

Serdecznie dziękuję opiekunowi pracy za wsparcie merytoryczne oraz dobre rady edytorskie pomocne w tworzeniu pracy.

Spis treści

1. Wstęp

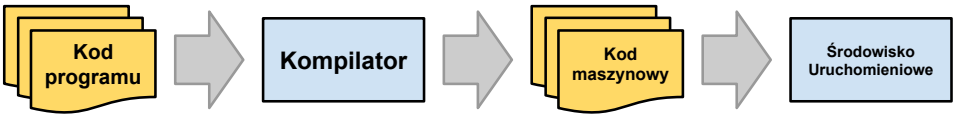
– describe the goal of the thesis - designing a programming language that:

  – elegantly solving heterogenuity issues

  – remains simple & highly ortogonal [[1]]

  – embodies Spartan Programming principles

– implementing its compiler



Rysunek 1.1: Schemat interakcji poszczególnych elementów języka.

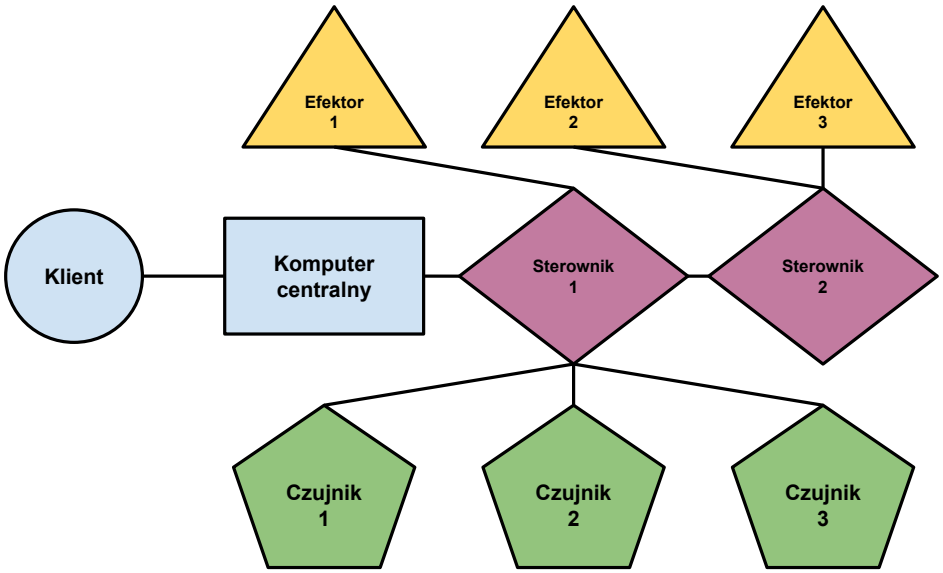
– implementing its runtime system

1.1. Motywacja pracy

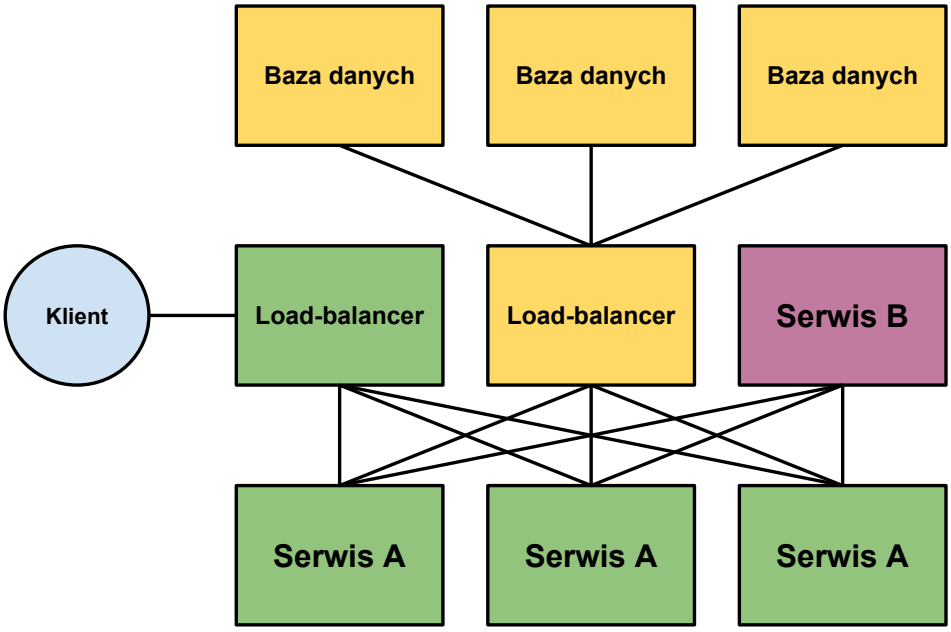
– name and describe challenges of distributed systems - `http://lycog.com/distributed-systems/challenges-distributed-systems/` [[2]] [[3]]

– Heterogeneity being incresingly important with rise of technologies such as IoT [[4]]

– Platform Independence being insufficient and/or impossible (vast number of very different devices)



Rysunek 1.2: Przykład systemu opartego o heterogeniczną platformę sprzętową.



Rysunek 1.3: Przykład systemu heterogenicznego niezależnie od platformy sprzętowej.

– Platform Awareness being the key (embracing the diversity)

– This language is supposed to solve heterogeneity using Platform Awareness.

1.2. Zawartość pracy

– list what is found where in the thesis

2. Język FOOF

- simplicity but not crudeness [[1]]
- pragmatism [[5]]
- platform awareness
- orthogonal features [[1]]
- contrast with Scheme/Lisp (and SML ?) [[6]]

2.1. Podstawowe typy danych

- describe lists - pairs of atoms|lists [[7]]
- describe numbers
- describe symbols
- describe strings
- describe vectors ?
- describe maps ?

2.2. Funkcje

- a note about lambda calculus [[8]] [[9]]
- add a code fragment implementing booleans in lambda calculus ?
- describe lambdas
- mention funarg problem [[10]]
- mention recursion problem [[11]] [[12]]
- describe named lambdas aka defines

2.3. Kontynuacje

– describe the notion of a continuation [[13]]

– briefly describe CPS transformation and comment on code equivalence [[14]]

– add a code example of the CPS transform

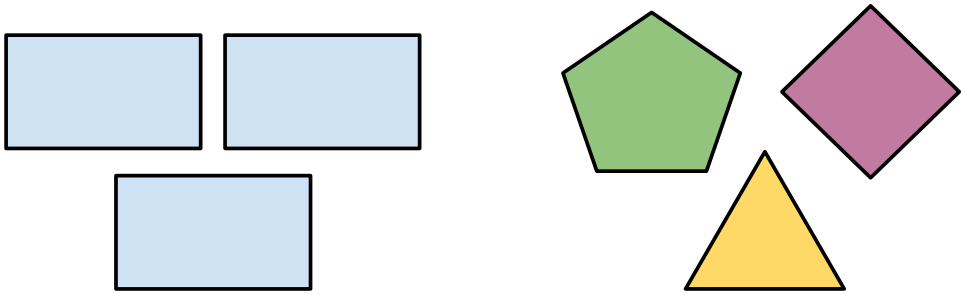
– hint at greater detail in a future section

– hint at delimited control [[15]]

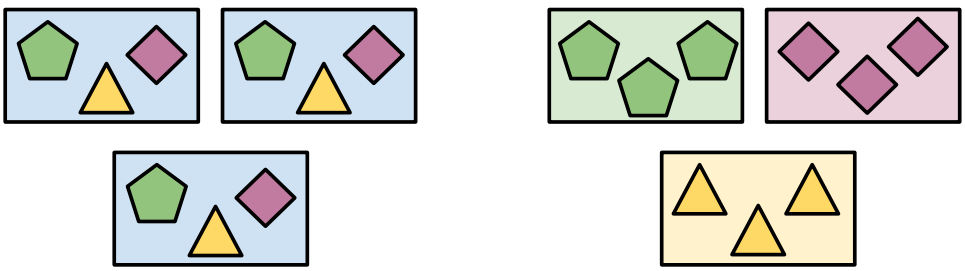
– describe exceptions via continuations

2.4. Przetwarzanie współbieżne i rozproszone

– briefly describe AMP vs SMP and contrast it with platform heterogeneity



Rysunek 2.1: Podstawowe różnice pomiędzy platformami homogenicznymi oraz heterogenicznymi.



Rysunek 2.2: Podstawowe różnice pomiędzy systemami asymetrycznymi i symetrycznymi.

– note that system doesn't need to run on a heterogenous platform to be heterogenous itself

– describe Actor Model [[16]] [[17]]

– describe processes via continuations (trampolines)

– describe actor model primitives [[16]]

– comment on adding distribution

2.5. Reprezentacja wiedzy w języku

– describe use cases in the language

– describe various ways of knowledge representation [[18]] [[19]] [[20]]

– describe primitive operations

– hint at using an RBS

2.6. Makra

– describe macros

– add some code examples of available macros

– hint at problems of hygiene & add code example [[21]] [[22]]

– hint at problems of macros & modules coexisting [[23]]

– contrast macros with other techniques (fexprs) [[24]]

2.7. System modułowy

– describe the need for a module system [[23]]

– describe structures - namespaces for definitions

– describe modules - parameterized structures [[25]]

– describe units - runnable modules

– describe protocols - a set of capabilities of a module

– hint at protocols & SOA connection ?

3. Kompilator języka FOOF

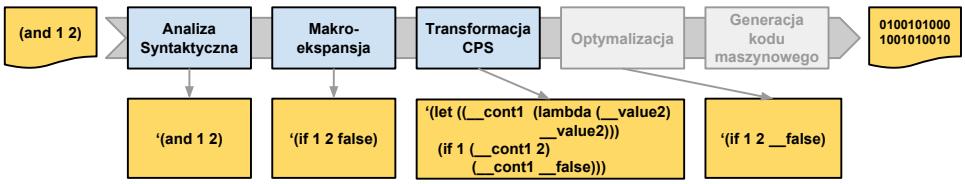
– mention technology selection & limitations (large project, little time) [[26]]

– mention possible bootstrapping

– briefly touch on the architecture [[27]]

– hint at using Scheme for the boring details (datatypes etc)

3.1. Architektura kompilatora



Rysunek 3.1: Schemat poszczególnych faz kompilacji i przykładowych danych będących wynikiem ich działania.

– list compilation phases [[27]] [[26]] [[14]]

– list which phases have been actually implemented

– list which phases have been skipped and say why (optimization, code-gen, parsing)

3.2. Parser

– briefly describe how Scheme praser works and what it produces [[6]] [[10]]

– hint at a possibility of replacing this with a PEG-based packrat [[28]] [[29]]

– note about special quasiquote syntax [[30]]

3.3. Makro-ekspansja

– describe macroexpantion phase

– describe why macroexpansion is hardcoded [[23]]

– list available macros

– show some examples of macro-expanded code

3.4. Obsługa Systemu Modułowego

– describe how modules are handled right now [[23]] [[25]]

– show some examples of macro-expanded structures & modules

– maby combine this with the previous section ?

– maby hint at special module access syntax (foo.bar.baz)

3.5. Transformacja *Continuation Passing Style*

– describe what CPS is [[14]] [[31]]

– describe in detail how to transform simple stuff

– describe in detail how to transform functions (recursion problems & crude solution via mutation [[32]], [[33]], [[11]])

– describe in detail how to handle exceptions

– describe in detail why this is useful (partial evaluation, constant folding etc) [[34]]

– hint at emitting calls to primitive functions `&yield-cont`, `&uproc-error-handler` etc

3.6. Generacja kodu

– describe how a subset of both Scheme and FOOF is emitted (contrast with Core Erlang) [[35]] [[36]]

– describe how Scheme is used for direct code execution

– hint at further development using LLVM [[**?**]]

– mention a requirement to perform closure conversion or lambda lifting [[37]]

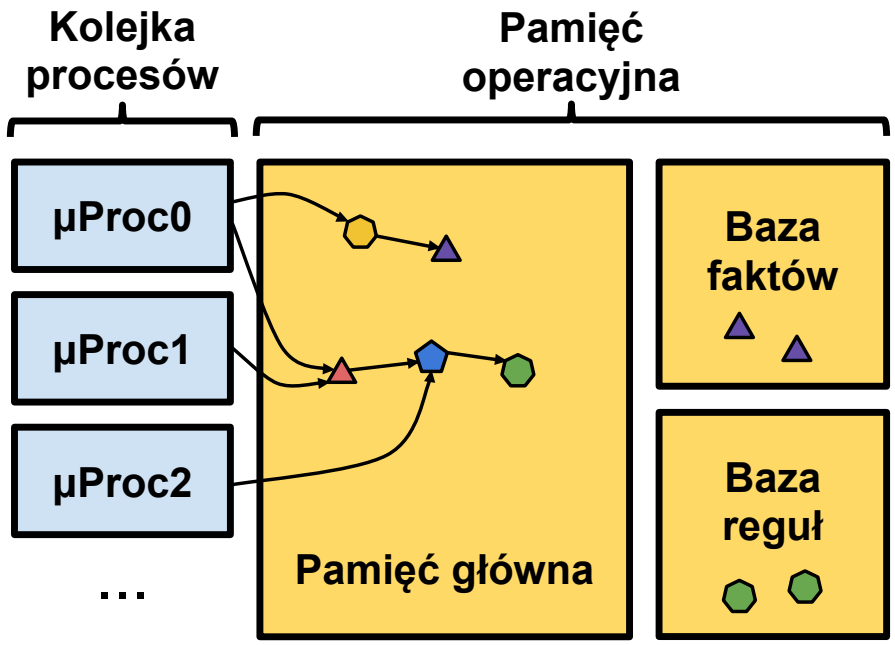
– add a code example contrasting closure conversion and lambda lifting

4. Środowisko uruchomieniowe języka

– briefly touch on the architecture

– mention Scheme bootstrap

4.1. Architektura środowiska uruchomieniowego



Rysunek 4.1: Schemat architektury środowiska uruchomieniowego języka FOOF.

– describe various parts

– mention that this is single threaded and requires forking for real concurrency

– hint at in-depth description of RBS implementation in a future section

4.2. Implementacja podstawowych typów danych

– describe scheme bootstrap [[6]]

– describe equivalence of various constructs such as lambdas

4.3. Implementacja kontynuacji

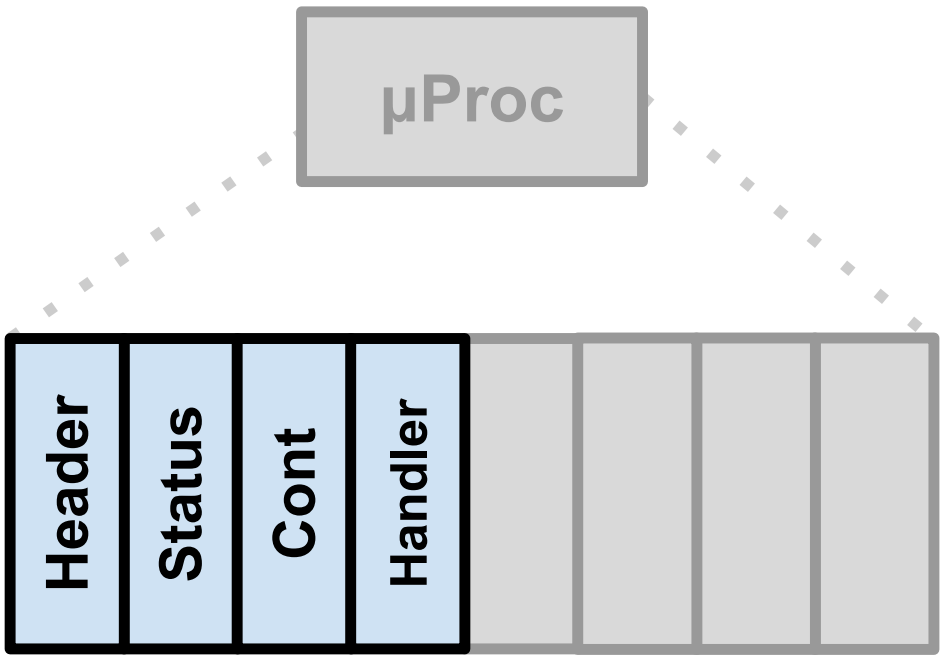
– describe how continuations are handled without getting into CFS (returning cont + hole aka trampoline, contrast to how G-machine/TIM reductions work) [[14]] [[37]]

– add a code example with step-by-step execution

– hint at debugging potential using step by step continuation execution with debug info inbetween

4.4. Implementacja procesów

– add a diagram of the uProc context - only include status, cont & handler registers



Rysunek 4.2: Schemat kontekstu procesu obrazujący rejestry niezbędne do jego działania.

– describe uProc context registers

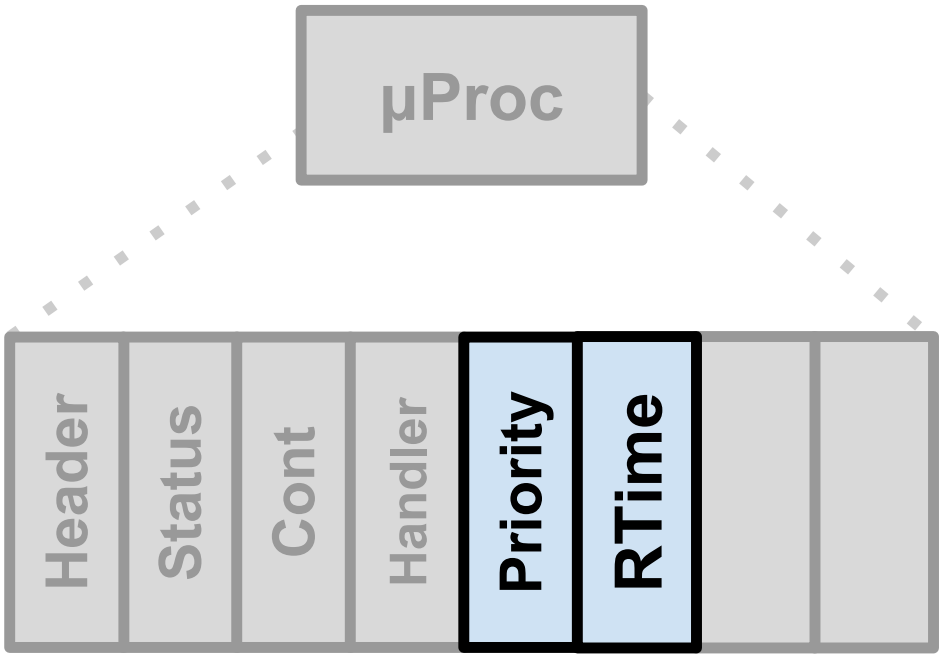
– describe how trampolines play into this scheme (recall `&yield-cont`)

– contrast trampolines with corutines (more suitable in CPS) and yielding (done implicitly) [[38]]

– describe how error handling is implemented (recall `&uproc-error-handler` etc)

– contrast with erlang [[39]]

4.5. Harmonogramowanie procesów



Rysunek 4.3: Dodatkowe rejestry kontekstu mikroprocesu wymagade do implementacji algorytmu *Completely Fair Scheduler*.

– describe the Completely Fair Scheduler [[40]]

– add pseudocode listing showing the algorithm

– describe uProc context switching

– contrast current impl with previous one (lack of wait list - notifications, heaps instead of RBT, number of reductions instead of time) [[41]]

– contrast with erlang [[39]]

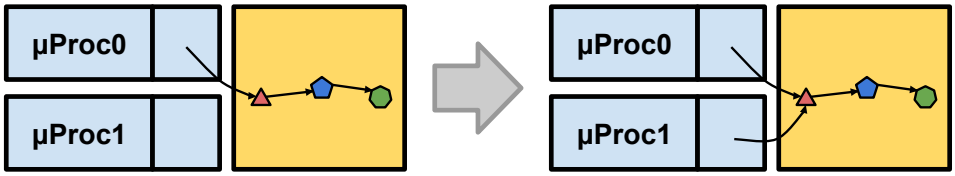
4.6. Implementacja Modelu Aktorowego

– describe actor model briefly [[16]] [[17]]

Rysunek 4.4: Dodatkowe rejestry kontekstu mikroprocesu wymagade do implementacji Modelu Aktorowego.

– describe modifications to the runtime required by actor model (**current-uproc**, uproc list, context fields)

– describe implementation of various actor model primitives



Rysunek 4.5: Diagram obrazujący efekty przekazywania wiadomości pomiędzy mikroprocesami.

– add some code examples and discussion of its effects and what happens

– contrast with erlang [[39]]

4.7. Dystrybucja obliczeń

– difference between concurrency & distribution

– describe modifications to the runtime in order to support distribution

– hint about using a simple protocol

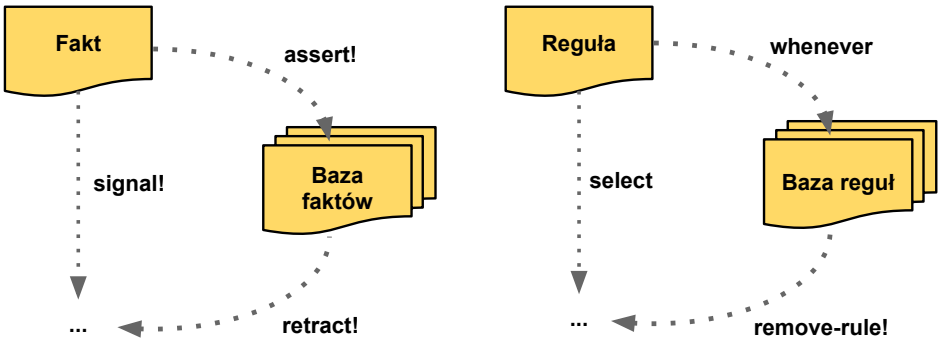
– hint about moving this into stdlib

5. Reprezentacja i przetwarzanie wiedzy

– describe how this needs a separate section

– elaborate on different ways of knowledge representation [[20]] [[42]] [[18]] [[?]] [[?]]

5.1. Reprezentacja wiedzy w języku



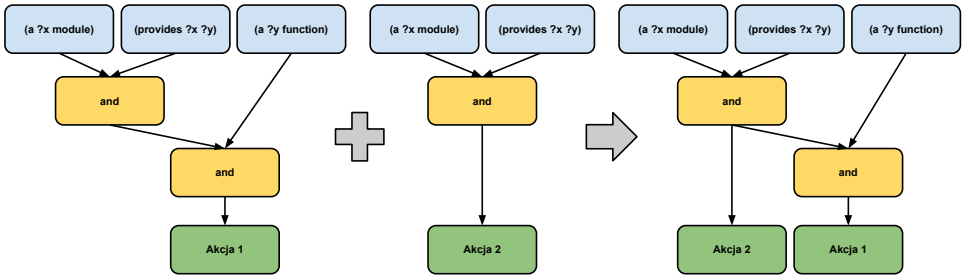
Rysunek 5.1: Schemat działania wbudowanych baz faktów i reguł.

– describe facts - signalling, assertion & retraction

– describe rules briefly - adding & disabling, triggering

5.2. Algorytm Rete

– describe in detail the algorithm [[43]]



Rysunek 5.2: Schemat łączenia podsieci w algorytmie *Rete*.

– describe briefly its history [[44]]

– Rete vs naïve approach (vs CLIPS or similar ?)

– add a benchmark diagram showing how Rete is better

– contrast it with other algorithms [[45]]

5.3. Implementacja Rete - wnioskowanie w przód

– describe what forward-chaining is

– describe naïve Rete - no network merging

– hint that this might be a good thing (future section)

– describe all the nodes [[43]]

5.4. Implementacja wnioskowania wstecz

– describe what backward-chaining is

– describe fact store in detail - linear, in-memory database

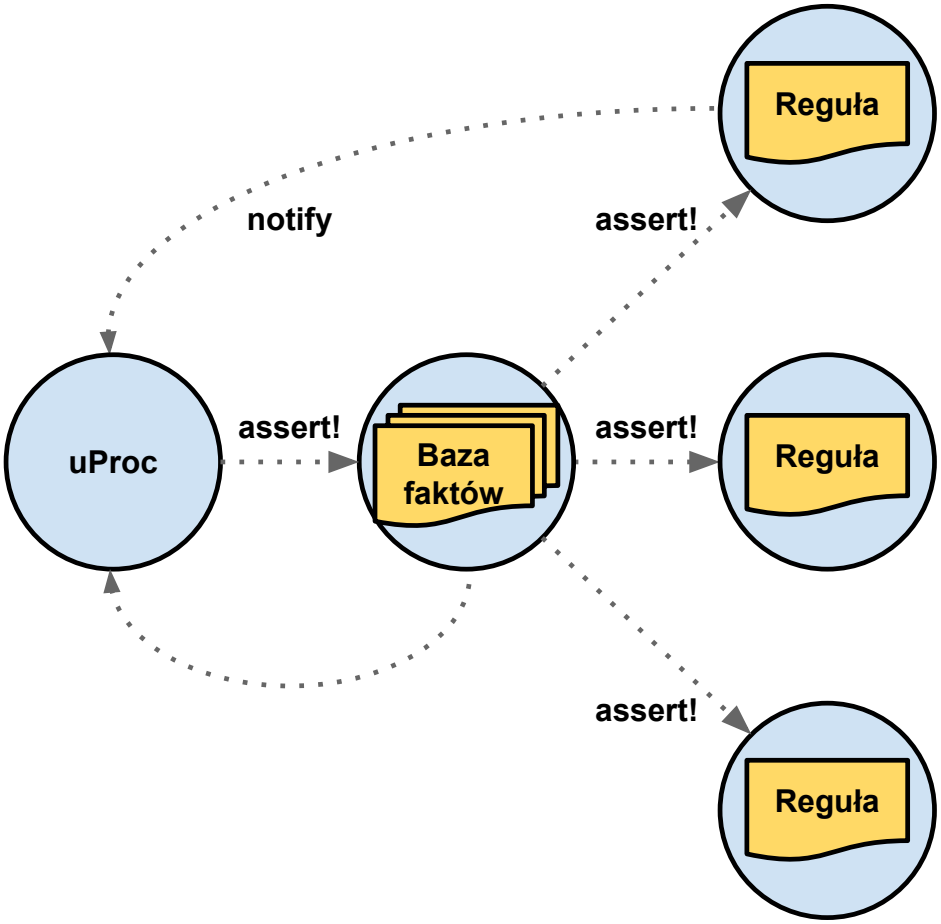
– querying fact store = create a rule and apply all known facts to it

5.5. Integracja z Systemem Uruchomieniowym

– describe how it sucks right now (notify-whenever instead of generic whenever, logic rule removal)

– describe possible integration with the module system (fact inference)

– describe possible representation of rules by autonomus processes [[46]]



Rysunek 5.3: Schemat działania rozproszonej wersji algorytmu *Rete*.

– hint at movig the implementation to the stdlib

6. Podsumowanie

– reiterate the goal of the thesis

– state how well has it been achieved

6.1. Kompilator języka FOOF

– needs better optimizations

– needs better error handling

6.2. Środowisko uruchomieniowe

– needs more stuff

– needs macroexpansion

– needs to drop RBS and move it into stdlib

6.3. Przyszłe kierunki rozwoju

– more datatypes

– native compilation via LLVM

– bootstrapping compiler

– librarized RBS

– librarized distribution with data encryption & ACLs

– data-level paralellism

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A. Gramatyka języka FOOF

– concrete language grammar in PEG or BNF

B. Przykładowe programy

- hello world
- some basic definitions & operations
- fibonacci
- parallell fibonacci
- module system - logger
- error handling - (raise (raise ”fight the powa”))
- RBS forward-chaining
- RBS backward-chaining
- task monitor example

C. Spis wbudowanych funkcji języka FOOF

– list contents of bootstrap.scm

– describe what `&make-structure`, `&yield-cont` etc do

D. Spisy rysunków i fragmentów kodu

Spis rysunków

Spis listingów