Q*cert

A platform for specifying and verifying query compilers

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Challenges?

Precise Language Semantics
Long Compilation Pipeline
Query Optimizer

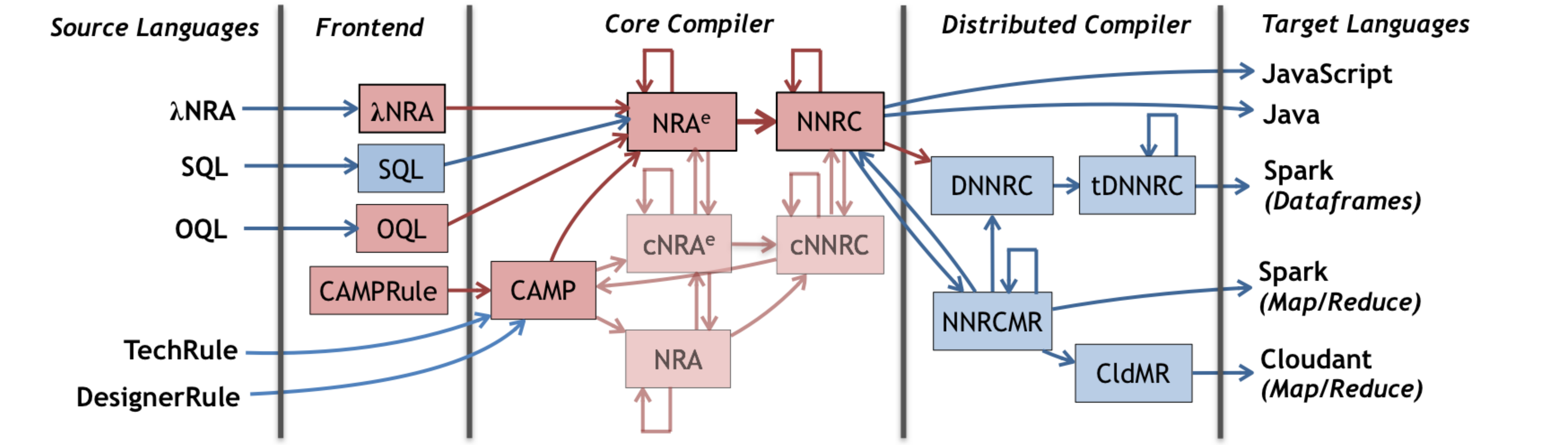
What for?

Correctness guarantees
New Languages (e.g., DSLs)
Education

How?

Formal Specification
Mechanized Proof
Code Extraction

Compilation Pipeline



Source Languages | Frontend | Core Compiler | Distributed Compiler | Target Languages

λNRA, SQL, OQL, TechRule, DesignerRule

λNRA, SQL, OQL, CAMPRule, CAMP

NRA^e, NNRC, cNRA^e, cNNRC, NRA

DNNRC, tDNNRC, NNRCMR, CldMR

JavaScript, Java, Spark (Dataframes), Spark (Map/Reduce), Cloudant (Map/Reduce)

SQL: Structured Query Language
OQL: Object Query Language
λNRA: NRA with Lambdas
CAMPRule: Rule Macros for CAMP
TechRule: ODM technical rules
DesignerRule: ODM designer rules

NRA: Nested Relational Algebra
NRA^e: NRA with Environments
cNRA^e: Core NRA^e
NNRC: Named Nested Relational Calculus
cNNRC: Core NNRC
CAMP: Calculus of Aggregating Matching Patterns

DNNRC: Distributed NNRC
tDNNRC: Typed DNNRC
NNRCMR: NNRC + Map/Reduce
CldMR: NNRC + Cloudant Map/Reduce

🟥 *with proof*
🟦 *without proof*

Algebraic Equivalence

```
Lemma select_union_distr q0 q1 q2 :
    σ⟨ q0 ⟩(q1 ∪ q2) ≡ σ⟨ q0 ⟩(q1) ∪ σ⟨ q0 ⟩(q2).
Proof.
  … (* proof omitted *)
Qed.
```

Functional Rewrite

```
Definition select_union_distr_fun q :=
  match q with
  | NRAEnvSelect q0 (NRAEnvBinop AUnion q1 q2) =>
      NRAEnvBinop AUnion
        (NRAEnvSelect q0 q1) (NRAEnvSelect q0 q2)
  | _ => q
  end.
```

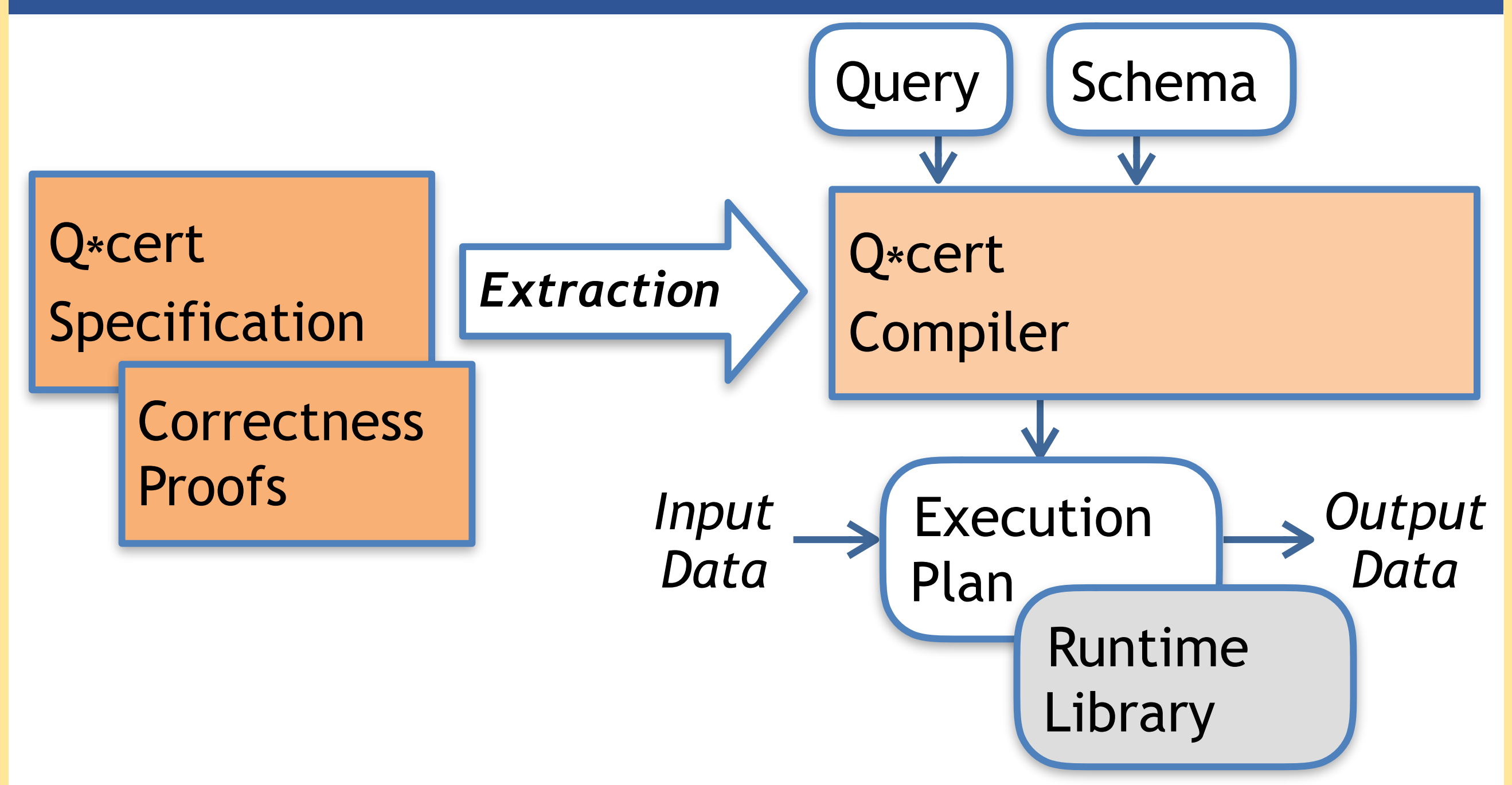
Correctness Proof

```
Property select_union_distr_fun_correctness q0 q1 q2 :
 select_union_distr_fun q ≡ q.
Proof.
 Hint Rewrite select_union_distr : envmap_eqs.
 prove_correctness q.
Qed.
```

Features

Nested Data Model with Objects
Type Checking
Aggregate Queries (includes TPC-H)
Configurable Optimizer
External Types and Functions
JSON Support

Compiler Extraction



Query, Schema

Q*cert Specification, Correctness Proofs

Extraction

Q*cert Compiler

Input Data, Execution Plan, Runtime Library, *Output Data*

The Coq Proof Assistant

https://querycert.github.io