



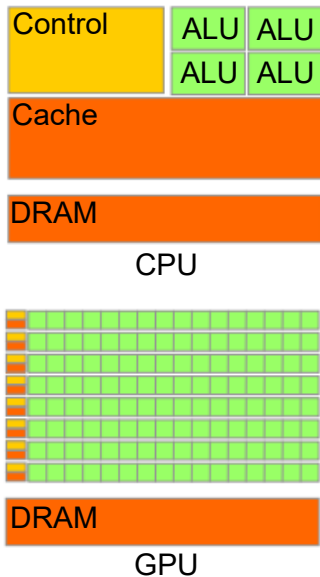
# F# OpenCL C Type Provider

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# GPGPU



General purpose computations on graphical processor units

- (Almost) SIMD architecture
- Huge amount of “simple” ALUs on single chip
- Initially for computer graphic/games
- Good choice for massive data processing

# General purpose applications of GPGPU

- Initially for scientific computations
  - ▶ Physics
  - ▶ Math
  - ▶ Chemistry
- But more and more for applications
  - ▶ Finance/Banking
  - ▶ Data Analytics and Data Science (Hadoop, Spark ...)
  - ▶ Security analytics (log processing)
  - ▶ Some scientific computations today are daily-used applications (bioinformatics, chemistry , ...)

# High level languages and GPGPU

Low-level platforms and languages  
for GPGPU programming

- NVIDIA CUDA: Cuda C, Cuda Fortran
- **OpenCL: OpenCL C**

High-level platform and languages  
for applications

- C++
- Python, Haskell, OCaml, ...
- JVM: Java, Scala, ...
- .NET: C#, F#, ...

# High level languages and GPGPU

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Interaction is a challenge!

# Possible solutions

- Translation of high-level language to GPGPU specific one
  - + Useful features of host language for GPGPU programming (type safety)
  - High performance GPGPU programs is inherently low-level
- Using of existing GPGPU libraries
  - + GPGPU optimized solution in low-level language
  - ? We need automatic generation of “well-typed” bindings

- F# quotations to OpenCL C translator
- Runtime
  - ▶ Command queue
  - ▶ Execution context management
  - ▶ Memory management
  - ▶ F# aliases for OpenCL-specific functions

# F# type providers

- Compile-time metaprogramming for types creation
  - ▶ Type provider is a **function which constructs type**
- Design-time features in IDE
  - ▶ Completion
  - ▶ Type information
- Used for type-safe integration of external data with fixed schema
  - ▶ Type providers for XML, JSON, INI
  - ▶ R, SQL



## Example of INI type provider

```
[Section1]
intSetting = 2
stringSetting = stringValue
[Section2]
floatSetting = 1.23
boolSetting = true
anotherBoolSetting = False
emptySetting =
stringWithSemiColonValue = DataSource=foo@bar;UserName=blah
```

```
open FSharp.Configuration
```

```
type Config = IniFile<"Config.ini">
```

```
Config.
```

ConfigFileName

Section1

Section2

type Section2 =

static member anotherBoolSetting : bool

static member boolSetting : bool

static member emptySetting : string

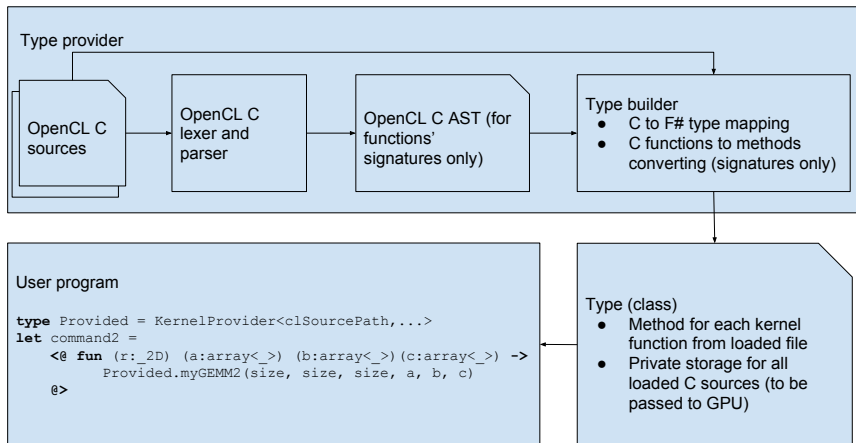
static member floatSetting : float

static member stringWithSemiColonValue : string

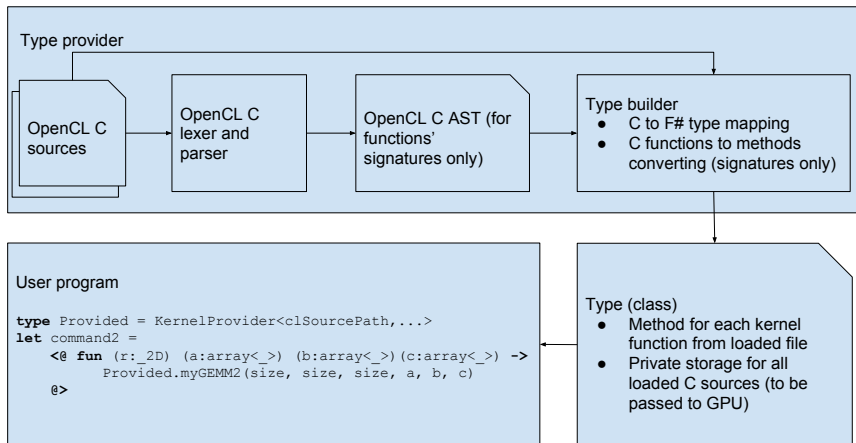
# OpenCL C type provider

- We want to construct type-safe wrapper for existing library
- OpenCL standard declares source-level distribution with in place compilation
  - + We can work with source code, not with binaries
  - Existing library is a set of files includes \*.h files
- It is enough to process functions signatures

# OpenCL C type provider: architecture



# OpenCL C type provider: architecture



Yes, it is typical type provider

# Limitations

- Only (small) subset of OpenCL C
  - ▶ \*.h files are not supported
  - ▶ preprocessor is not supported
  - ▶ only small subset of syntax is supported
- Very simple C to F# type mapping

# Examples

```
// TypeProvider configuration
let constantsPath = __SOURCE_DIRECTORY__ + "/constants.h"
let [<Literal>] clSourcePath = __SOURCE_DIRECTORY__ + "/mygemm.c"
type ProvidedType = KernelProvider<clSourcePath, TreatPointersAsArrays=true>
```

# Examples

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type ProvidedType = KernelProvider<clSourcePath, TreatPointersAsArrays=true>

let command2 =
    <@
        fun (r:_2D) (a:array<_>) (b:array<_>) (c:array<_>) ->
            ProvidedType.myGEMM2(newSize, size, size, a, b, c)
    @>
```

This expression was expected to have type  
int  
but here has type  
float

# Examples

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let command2 =
    <@
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            ProvidedType.
    @>
```

myGEMM1    KernelProvider<...>.myGEMM1(M: int, N: int, K: int, A: float32 [], B: float32 [], C: float32 []) : unit

myGEMM2

myGEMM3

myGEMM5



# Future work

- Improve OpenCL C support
  - ▶ Lexer and parser
  - ▶ Translator
  - ▶ Types mapping
  - ▶ Headers files processing
  - ▶ ...
- Unify kernels on client side
  - ▶ Currently native Brahma.FSharp's kernel and kernel loaded by type provider are different types
- Improve mechanism of kernels composition

# Summary

- F# OpenCL C type provider
  - ▶ Type-safe integration of existing OpenCL C code in F# applications
  - ▶ Proof of concept
- Source code on GitHub:  
<https://github.com/YaccConstructor/Brahma.FSharp>
- Package on NuGet:  
<https://www.nuget.org/packages/Brahma.FSharp/>

- Semyon Grigorev: [s.v.grigoriev@spbu.ru](mailto:s.v.grigoriev@spbu.ru)
- Kirill Smirenko: [k.smirenko@gmail.com](mailto:k.smirenko@gmail.com)
- Brahma.FSharp:  
<https://github.com/YaccConstructor/Brahma.FSharp>

Thanks!