Introduction to Named Function Networking

Claudio Marxer
<claudio.marxer@unibas.ch>

Christopher Scherb
<christopher.scherb@unibas.ch>

Christian Tschudin
<christian.tschudin@unibas.ch>

Computer Networks Group · University of Basel · Switzerland

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Users want Results, not Data!

Trick: "Name the Result" by specifying how to obtain it.

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. . . and let the network orchestrates the result generation:

- Name Rewriting
- Disassembly into Sub-Computations
- Moving Code
- Executing Code

...

Example 1, Client's Perspective for "get duration"

Named Data Networking: Distribution of named content (published)

```
lookup:  /joe/NYmarathon/track.gpx
```

Named Function Networking (NFN): Generation of named content (on-demand)

```
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         ^^^^^^^^^^^^^  ^^^^^^^^^^^^^^^^^^^^^^^^^
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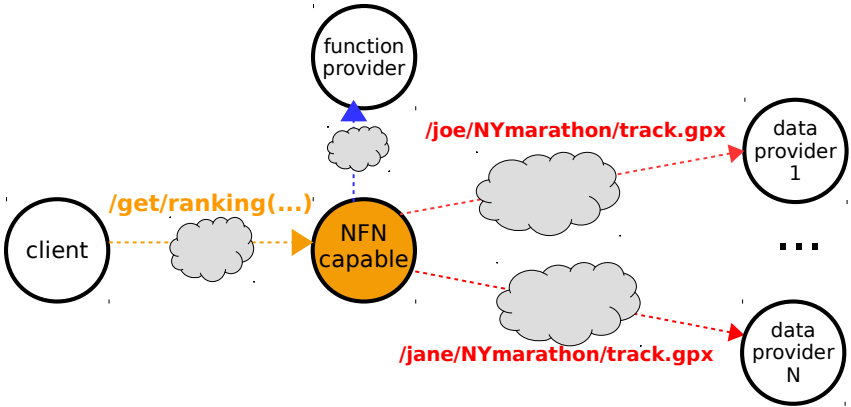
```
lookup:  /joe/NYmarathon/track.gpx
INTEREST[ name ]
```

Named Function Networking (NFN): Generation of named content (on-demand)

```
lookup:  /get/duration( /joe/NYmarathon/track.gpx )
         named function   named content
INTEREST[ expression ]
```

Example 2, Network's Perspective for "rank two runners"



Special NFN-capable nodes dissect the interest's NFN name and orchestrate the result derivation.

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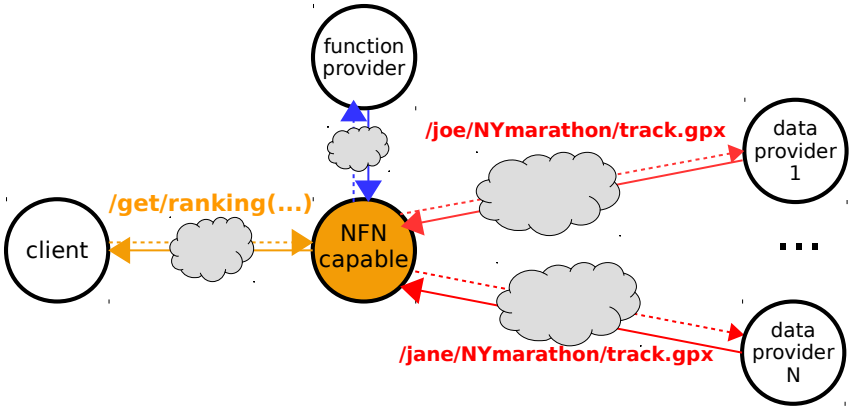

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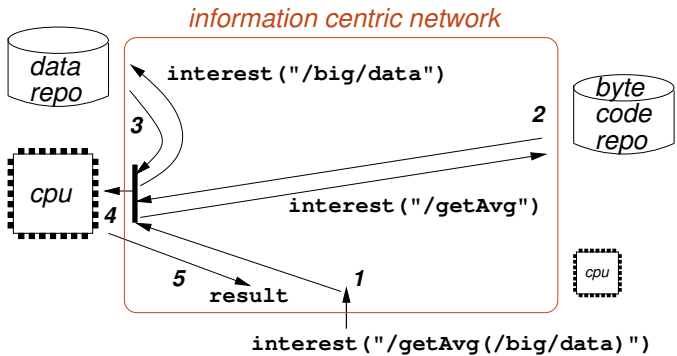
From Name-Resolution (NDN) to Expression-Reduction (NFN)

Realm	*Instances*	*Network Semantics*
Named Data *(access to data)*	"classic" ICN, key–value store, DNS	"name resolution" (= lookup)
Named Functions *(access to results)*	"new" ICN	"expression reduction" (= processing)

Three Tasks for doing “reduction in the network”: Locate (data, fct and exec place) / Run / Collect

e.g. Find a server close to the DB (instead of downloading tera bytes), execute there.



Network does **not** execute: NFN only **orchestrates** the computation

What is Really new in NFN?

- User-Formulated Content Names

  Building Blocks: Named-Functions, Content (static or dynamic)
  Glue: Extended λ-Calculus

- Provides On-Demand / Dynamic / Derived Content

- Requires NFN-capable nodes (doing the expression reduction):

  Purpose: Derivation of derived content

- Caching of computation results (since done in-network)

NFN's reduction task, at a glance

`f( a , g(b) )` a, b are content objects; f, g are named functions

Reduced by launching three activities:

- hunt for `f`
- hunt for `a`
- reduce `g(b)` recursively

The King of Reduction: Famous λ-Calculus (1930ies)

λ-calculus recap slide, also for functional programming novices (LISP, Haskel, etc)

A λ-calculus expression E has one of three forms:

1. $E \stackrel{\text{def}}{=} a$ — variable a
2. $E \stackrel{\text{def}}{=} f(e)$ — result of function f applied to expr e
3. $\mathbf{E} \stackrel{\text{def}}{=} \lambda\mathbf{x.e}$ — a function defined by expr e with parameter x

The last case will be important for the NFN tutorial track:
It permits to move a name (inside the expression) in front of that expression,
hence influence the routing (as we will see).

Outline

- NFN Mindset
- Client's Interface to NFN
- Implementation: `nfn-scala`

How to Map a NFN Expressions to one NDN Name..

Building Blocks:

- Named Content: Data to derive from
- Named Functions: Derivation procedure inside a content object
  - Side-effect-free mapping: Content object(s) $\rightarrow$ Content object
  - Bytecode of a JVM function.

Glue:

- λ-Calculus: Formal language to describe computations
- Additional `call` operator: To express a named function invocation.

The `call` Operator

```
call <num> <fct> <arg1> <arg2> ...
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Examples:

```
call 2 /fct/wordCount "hello world"
call 2 /fct/wordCount /nice/poem.txt
call 2 /fct/wordCount (call 2 /fct/firstVerse /nice/poem.txt)
```

NFN Expressions = Structured Names

Recipe to get a network name:

1. Reformulate: Prepend one of the network names (λ abstraction and application)
2. Split into Name Components

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Example (One Expression: Different Mappings $\rightarrow$ Different Forwarding Behavior)

– Prepended function name:

1. `/fct/wordCount @x call 2 x /nice/poem.txt` (λ-expression)

– Prepended argument name:

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Example (One Expression: Different Mappings $\rightarrow$ Different Forwarding Behavior)

- Prepended function name:
  1. `/fct/wordCount @x call 2 x /nice/poem.txt` (λ-expression)
  2. `/fct/wordCount/@x call 2 x /nice/poem.txt/NFN` (network name)
- Prepended argument name:
  1. `/nice/poem.txt @x call 2 /fct/wordCount x` (λ-expression)
  2. `/nice/poem.txt/@x call 2 /fct/wordCount x/NFN` (network name)

How to Implement a Named Function?

In our current system, named functions are implemented in Scala and published as JVM Bytecode (but could also be written in Python...)

```
class WordCount() extends NFNService {
  override def function(interestName: CCNName, args: Seq[NFNValue], ccnApi: ActorRef): NFNValue = {
    def splitString(s: String) = s.split(" ").size

    NFNIntValue(
      args.map({
        case doc: NFNContentObjectValue => splitString(new String(doc.data))
        case NFNStringValue(s) => splitString(s)
        case NFNIntValue(i) => 1
        case _ =>
          throw new NFNServiceArgumentException(s"No words to count!")
      }).sum
    )
  }
}
```

Write your first named function in the following hands-on track!

Q & A