# Language support for context-aware computations

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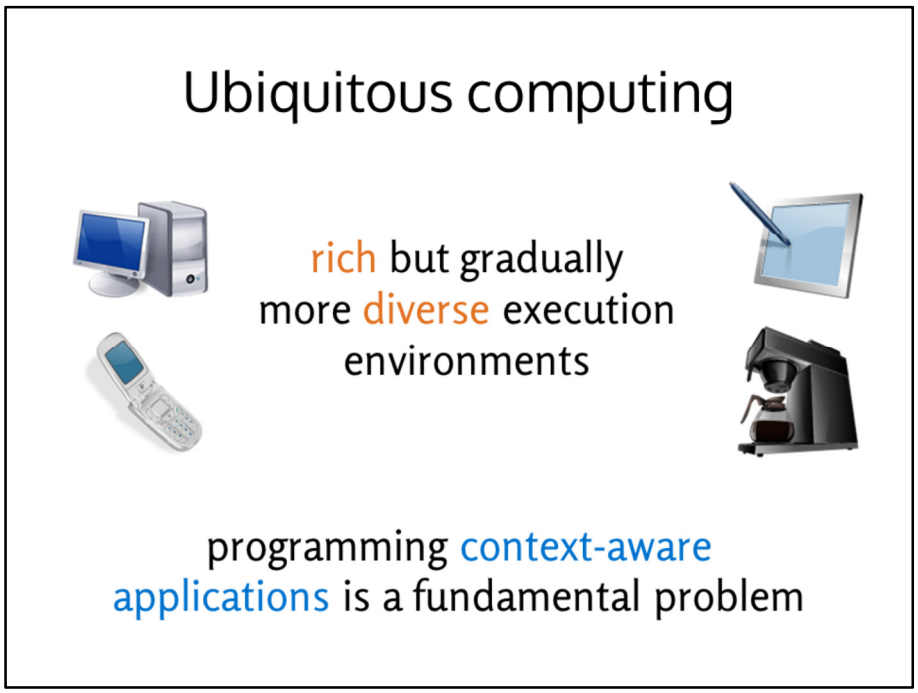
## About me

- 3rd year PhD student working in programming languages group
- Contributor to open-source projects & functional programming speaker
- Worked on the F# language during Microsoft Research internships

## This proposal

- Programming languages for modern heterogeneous applications
- Developed mathematical foundations for context-aware computations
- Useless without practical implementation!

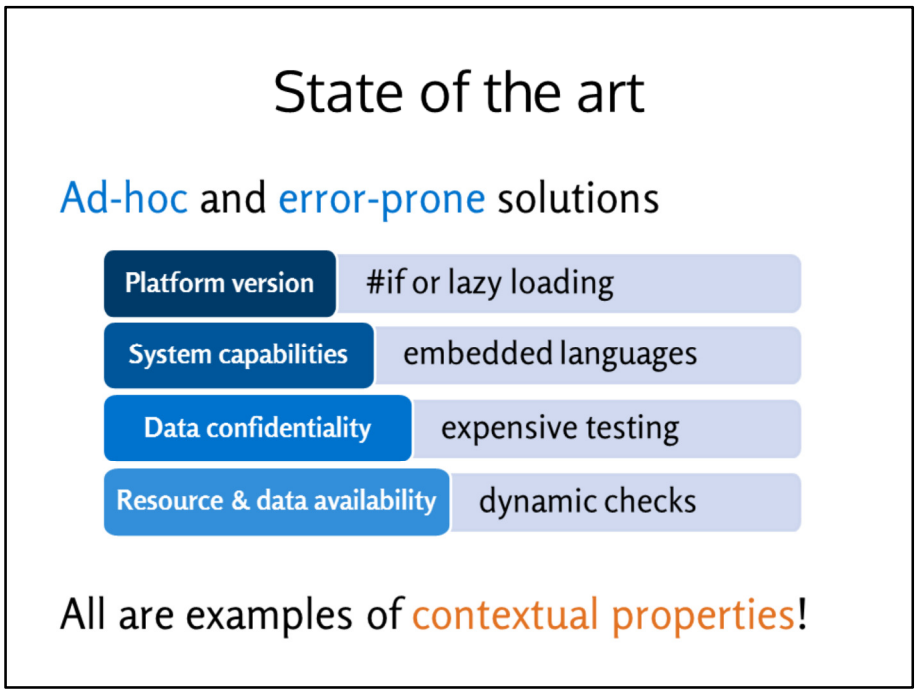



## Modern applications

- Run in a heterogeneous environments, across multiple devices
- Must be aware of the context: GPS sensor, computing capabilities

## Future directions

- **Diversity:** mobile application for multiple platforms
- **Internet of things**: even more diverse environments
- **Specialized hardware:** offload computations to GPU, FPGA?

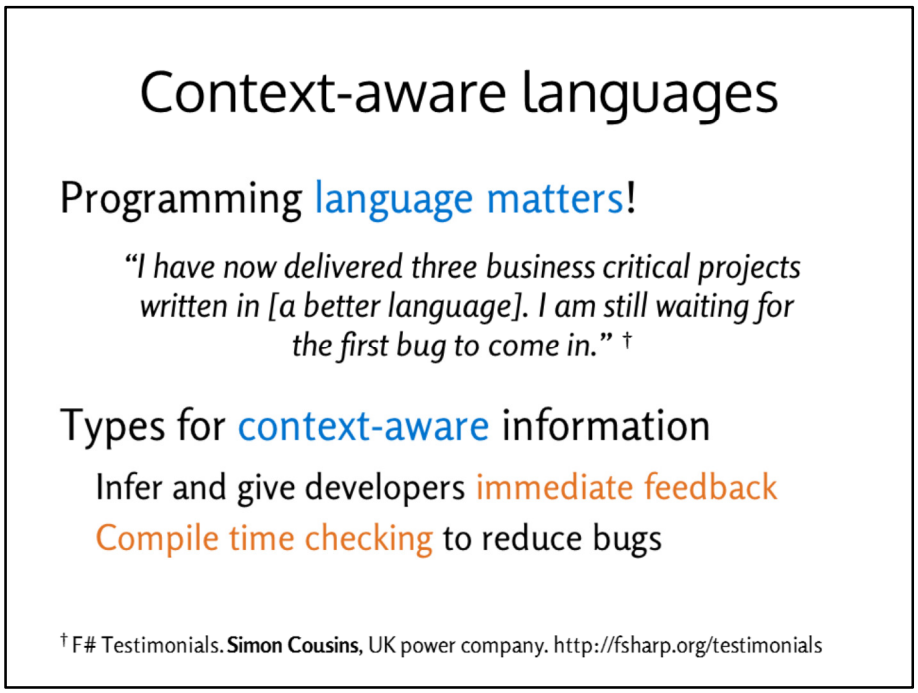



## Heterogeneous development today

- **Platform version:** cross-compilation using #if leads to maintenance nightmare; loading components at runtime can easily lead to runtime errors
- **System capabilities:** when calling SQL or GPU, code in embedded (domain-specific) languages is translated at runtime; this translation often fails
- **Data confidentiality:** you do not want to send your database password over unsecured network - this needs to be checked at compile time
- **Resource & data availability:** does a function require GPS sensor or database access to run? what will happen if resources are unavailable?

## Contextual properties

- Capture information about the context (resources, safety constraints, platform requirements and more...)

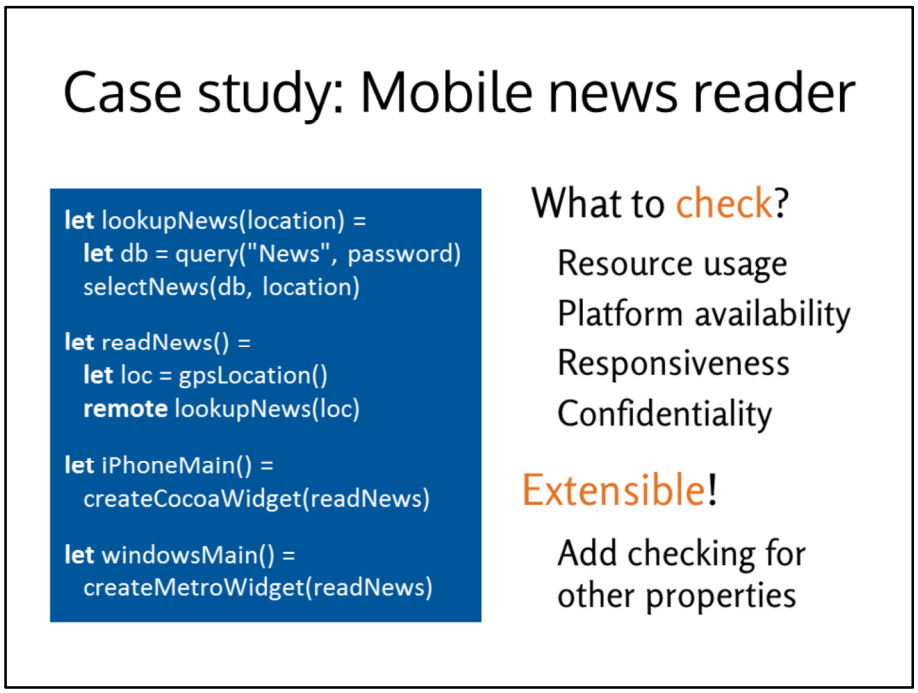



## The quote

- Talk about F# - typed functional language with strong checking
- F# types are inferred – the code is concise, but safe
- F# types are powerful – for example, check units of measure
- Follow the same powerful design principles for context-aware computations

## Types for context-aware information

- Integrating context at the language level enables many scenarios
- Type checking – detect bugs at compile time
- Advanced editors – give immediate code information & error feedback

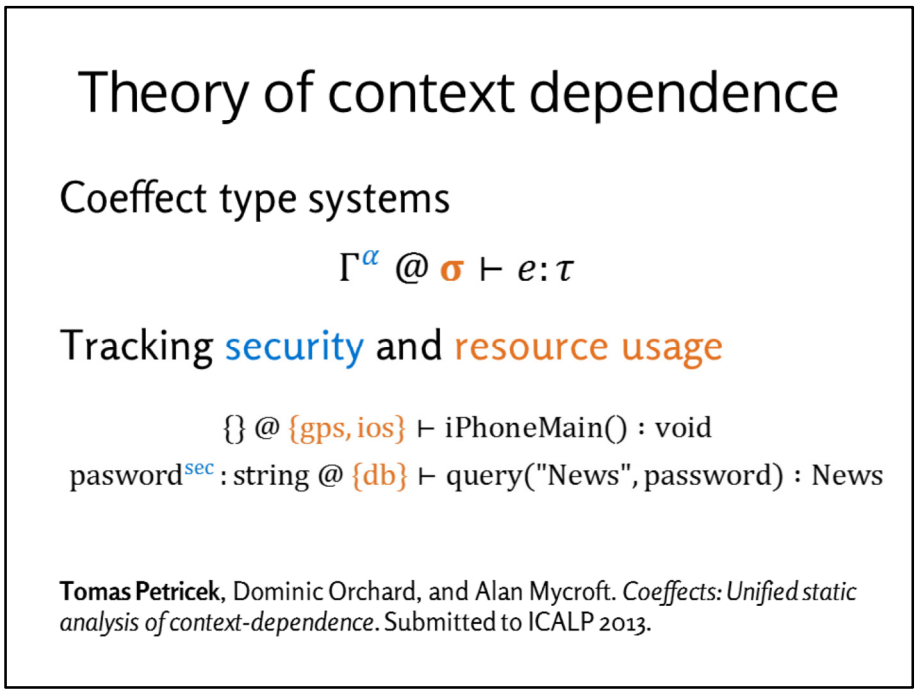



## Case study

- **lookupNews** requires database – it needs to run on the server-side (**remote** call), **readNews** requires GPS
- **iPhoneMain** needs iOS and **windowsMain** needs Metro, but **readNews** can be shared between the two
- **readNews** makes call to the server, so it must be called on background thread to avoid blocking the user interface
- **password** is used in database connection and so it is confidential (cannot be used in all contexts)

## What to track

- Set of resources used, minimal platform version required
- Not a closed set – users want to add more properties!




## Coeffect typing judgment

Generalization of so-called effect systems

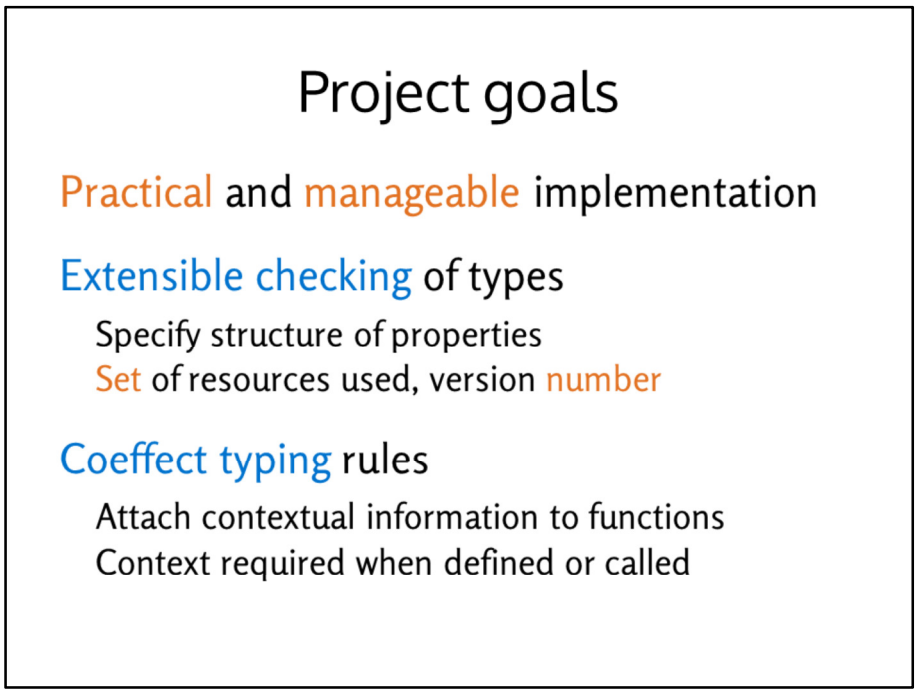
- Effect systems capture how programs affect the world
- Coeffect systems capture what is required from the world

The expression $e$ returns a value of type $\tau$ provided that:

- It has variables $\Gamma$ annotated with security information $\alpha$
- It is running in a context that satisfies $\sigma$

## Two examples

- **iPhoneMain** call requires GPS and iOS platform and does not return anything
- **query** call requires database (db) access and a string variable **password** that must be marked as confidential

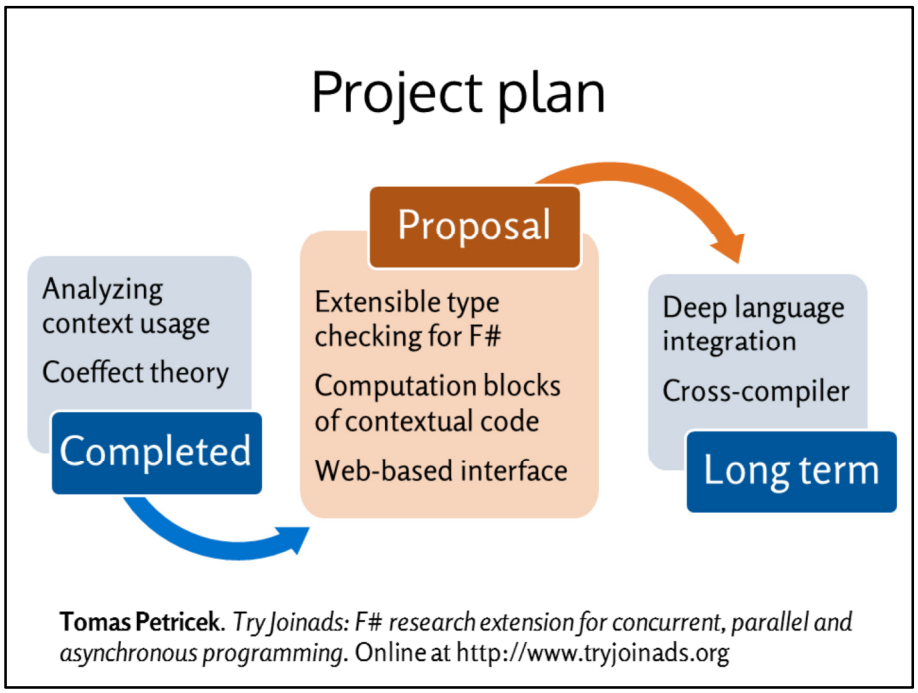



## Practical approach

- Produce something that developers can play with
- It should not be a single-purpose prototype!
- Compiler tool-chain in a year is impossible...

## Extending the F# compiler

- Annotate types with custom *checked* information
- Type checking rules for sets of resources, versions, etc.
- Embedded code blocks that track contextual information




## Completed so far

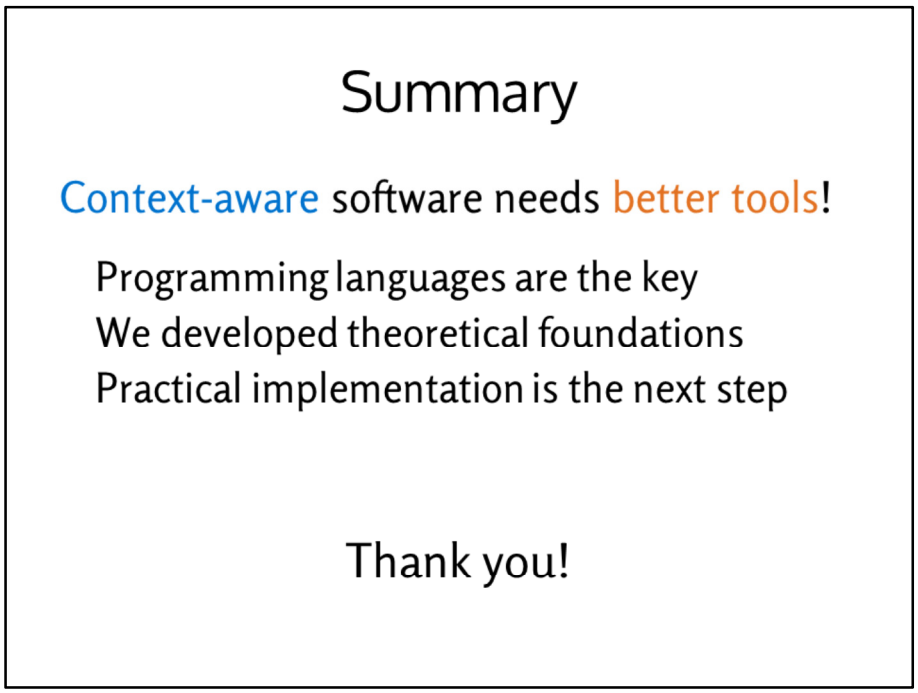
- Analyze how context is used in computations
- Coeffect theory to capture context dependence

## One year goals

- Extensible checking that can reason about sets, numbers, monoids, …
- Code blocks can be translated to GPU, JavaScript, etc.
- Available via the web – I did that for my earlier project

## Long-term goals

- Track contextual information for a whole program
- Cross-compiler that produces iOS, JVM, .NET, JavaScript, CUDA, etc.




## Summary

- Context-awareness is fundamental – we need to integrate it at the low level
- Programming languages enable better compilers and tools
- Coeffect theory captures context-dependent properties

## Fellowship proposal

- Add context-aware extensions to the F# language
- Make it available for experimentation via the web

**Thank you!**