

# CSE 341: Programming Languages

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Lecture 12— Modules and Abstract Types

# Modules

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Large programs benefit from more structure than a list of bindings.

Breaking into parts allows separate reasoning:

- Application-level: in terms of module (in ML, structure) invariants
- Type-checking level: in terms of module types
- Implementation level: in terms of module code-generation

By providing a *restricted* interface (in ML, a signature), there are *more* equivalent implementations in terms of the interface.

Key restrictions:

- Make bindings inaccessible
- Make types abstract (know type exists, but not its definition)

SML has a much fancier module system, but we'll stick with the basics.

Abstract types are a “top-5” feature of modern languages.

## Structure basics

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Syntax: `structure Name = struct bindings end`

If `x` is a variable, exception, type, constructor, etc. defined in `Name`, the rest of the program refers to it via `Name.x`

(You can also do `open Name`, which is often bad style, but convenient when testing.)

So far, this is just *namespace management*, which is important for large programs, but not very interesting.

# Signature basics

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(For those interested in learning more, we're doing only *opaque signatures* on structure definitions.)

A signature `signature BLAH = sig ... end` is like a type for a structure.

- Describes what types a structure provides.
- Describes what values a structure provides (and their types).

Writing structure `Name :> BLAH = struct bindings end`:

- Ensures `Name` is a legal implementation of `BLAH`.
- Ensures code outside of `Name` assumes nothing more than what `BLAH` provides.

Hence signatures are what really enable separate reasoning.

# Signature matching

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Is Name a legal implementation of BLAH.

- Clearly it must define everything in BLAH.
- It can define more (unavailable outside of Name).
- BLAH can restrict the type of polymorphic functions.
- BLAH can make types abstract.

In particular, making a datatype abstract hides the constructors, so clients have no (direct) way to create or access-parts-of values of the type.

That's often a good thing.

## Remember

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A signature that “hides more” makes it easier to:

- Replace the structure implementation without breaking clients.
- Reason about how clients use the structure.

Note: The real “content” of this lecture is in the extended example.