Basic lambdas for C (slides)
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Basic lambdas for C
ISO/IEC JTC 1/SC 22/WG14 N2892
WG21 P2303

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https://modernc.gforge.inria.fr/
Policy

- extend the standard
  - valid code remains valid
  - new feature integrates syntactically and semantically
- fix as much requirements as possible through constraints
  - specific syntax
  - explicit constraints
- avoid new undefined behavior
  - only, if property is not (or hardly) detectable at translation time
  - or we leave design space to implementations
- don’t mess with ABI
  - no changes
  - no extensions
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Example: simple function literal

```c
char const* stringArray[NUMEL];
...
qsort(stringArray, NUMEL, sizeof(stringArray[0]),
    [](void const* a, void const* b){
        char const*const* A = a;
        char const*const* B = b;
        return strcmp(*A, *B);
    });
```

- function literal appears close to its use
- return type is inferred as the same as `strcmp`
- function literal is converted to function pointer

```c
int (*)(void const* a, void const* b)
```

- that function pointer is passed into `qsort`
Example: iterated function literal

```c
auto strSort = [](size_t n, char const* stringArray[n]) {
    qsort(stringArray, n, sizeof(stringArray[0]),
          [](void const* a, void const* b){
              typeof(stringArray[0]) const* A = a;
              typeof(stringArray[0]) const* B = b;
              return strcmp(*A, *B);
          });
};
```

- a lambda expression that sorts string pointers
- the outer lambda has no `return` => return type is `void`
- use of `sizeof` and `typeof` makes it type safe (no evaluation!)
- no function with `void*` parameters is exported
- may be used directly in a function call
- may be converted to a function pointer

```c
void (*) (size_t n, char const* stringArray[n])
```
Example: value closure

- value captures are evaluated when the lambda expression is met

```
// freeze \( \epsilon \) to \( \delta \) and have the function parameter dependent
auto const \( \lambda5\epsilon = [\delta = \epsilon](\text{double } x, \text{typeof}(x) \text{ func}(\text{typeof}(x))) \) {
    double \( h = \delta \times x; \)
    return \((-\text{func}(x+2*\delta)+8*\text{func}(x+\delta)-8*\text{func}(x-\delta)+\text{func}(x-2*\delta))/(12*\delta); \)
};
```

- even if the capture is itself a lambda value

```
// also freeze a function, and have the parameter dependent
auto const \( \lambda5\_\text{func} = [\delta = \epsilon, \text{ func } = f](\text{typeof}(\text{func}(0)) x) \) {
    auto \( h = \epsilon \times x; \)
    return \((-\text{func}(x+2*\epsilon)+8*\text{func}(x+\epsilon)-8*\text{func}(x-\epsilon)+\text{func}(x-2*\epsilon))/(12*\epsilon); \)
};
```

- this works if \( f \) is a function, function pointer or lambda
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Design choices

Design choice, expression

Function definitions versus expressions

- function definition
  - naming is a burden
  - function use is distant from definition
  - nested functions may access all outer variables (no control mechanism)

- expression
  - anonymous
  - use where defined
  - lambda expression:
    - dedicated syntax to control access to outer variables

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Design choices

Capture model

- **visibility** of (almost) all identifiers as usual
- **access** is different
  - identifiers with linkage => business as usual
  - static identifiers without linkage => ok if not VM
  - automatic variables: default is *no capture* ([], function literal)
  - value capture by explicit request ([hui = fui])
  - identifier capture by explicit request ([&hui])
  - options N2893
    - shadow capture by explicit request ([bla])
    - *capture all* as identifier capture ([&])
    - *capture all* as shadow capture ([=])
Design choices, function call

- Lambda values are only visible in the same TU
- Escape from TU only if function literal and converted to function pointer
- Closure => addressless *static* function with *no escape* guarantee
- No ABI change
Design choices

Interoperability
- all is fixed at *translation time*
- no linker dependency

Not available
- recursion only if function literal via function pointer
- `stdarg` no variable argument list allowed
- `VM types` would be evaluated
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Deviation from C++ – maybe added later

No return type specification

- C++ has the syntax “→ return-type” as in

```cpp
[](double x, double h, double (*func)(double)) -> double {
  return (-func(x+2*h)+8*func(x+h)-8*func(x-h)+func(x-2*h))/(12*h);
}
```

Make captures mutable

- C++ has the keyword `mutable`

```cpp
[δ = ε](double x, double (*func)(double)) mutable {
  if (condition) δ += 1.E-7;
  double h = δ * x;
  return (-func(x+2*h)+8*func(x+h)-8*func(x-h)+func(x-2*h))/(12*h);
}
```
### Existing extensions

#### C++ and widely used gcc extensions

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