The Three R's: Redis, Rust & Raft

Uri Shachar, Director of Software Engineering, Redis

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Introductions

Uri Shachar

Senior Director of Software Engineering, Redis.

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Agenda

1. Redis - The OSS & The company
2. Rust @ Redis
3. Replacing Redis Cluster with Raft based mechanism

Our Roots are in Open Source

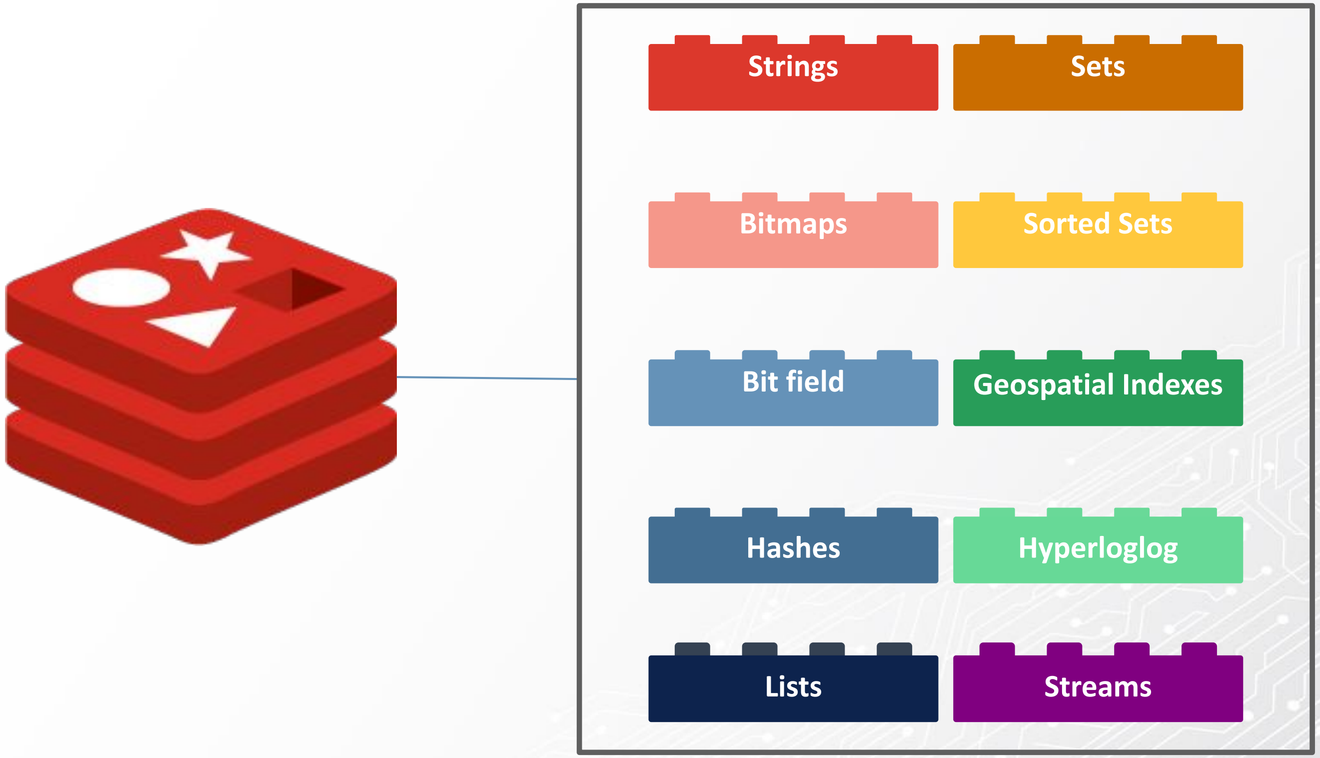
An **In-memory open source database**, supporting a variety high performance operational, analytics and hybrid use cases

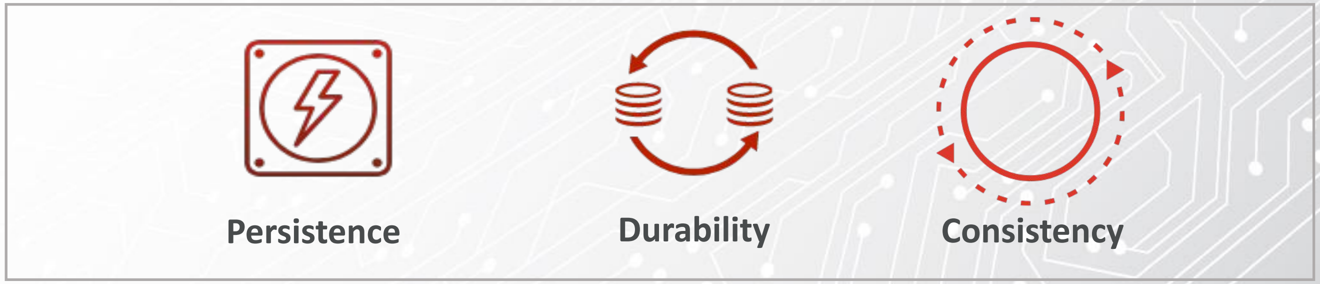
Redis OSS

Commonly used for:

- Cache
- Message bus (Pub/Sub)
- Session store
- Leaderboard
- Distributed Lock
- Job Queue
- …

Redis Data Structures





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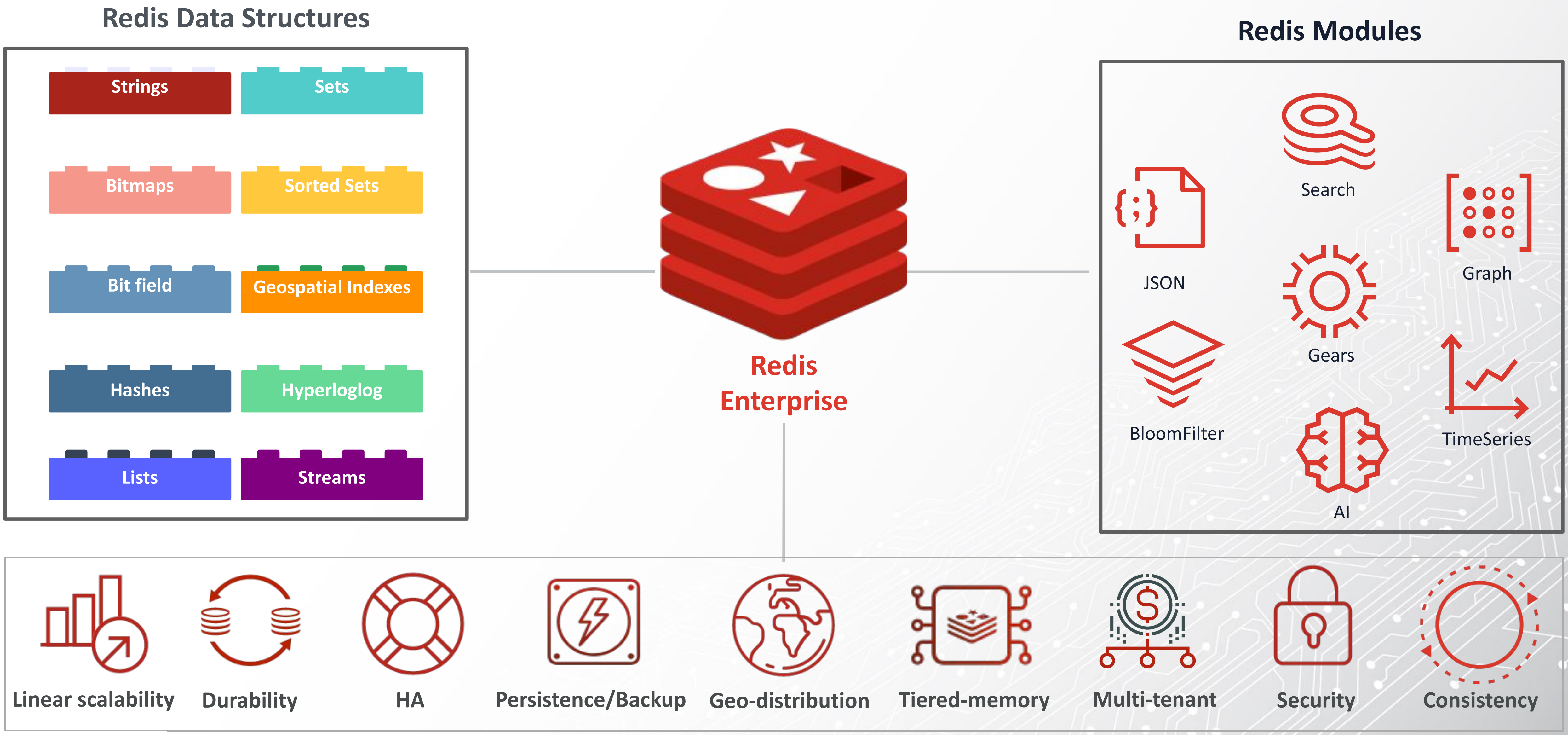
Redis



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Available Everywhere

On major CSPs (either directly or via partnerships) as a managed product.

And as software.

Google Cloud

Amazon Web Services

Microsoft Azure

VMWare Tanzu

Kubernetes

RedHat OpenShift

Bare Metal / VM

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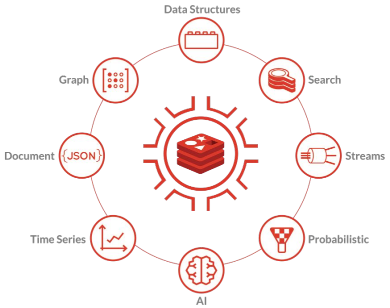
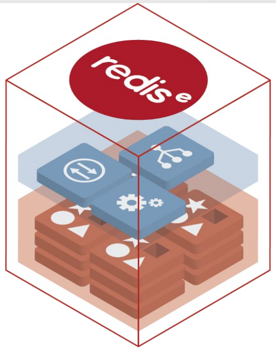
Rust @ Redis



Modules

- Redis module interface
- ReJSON
- Other



Control plane

- New projects
- Quorum management
- Authentication

Core

- New Redis Clustering
- Client libs (redis-rs)
- More coming…

Rust @ Redis

Specifically, my team is working almost entirely in Rust:

- K8s Operators for managing Redis at scale
- Control plane processes for managing and monitoring Redis instances
- Component testing framework & tests
- New Redis Clustering implementation

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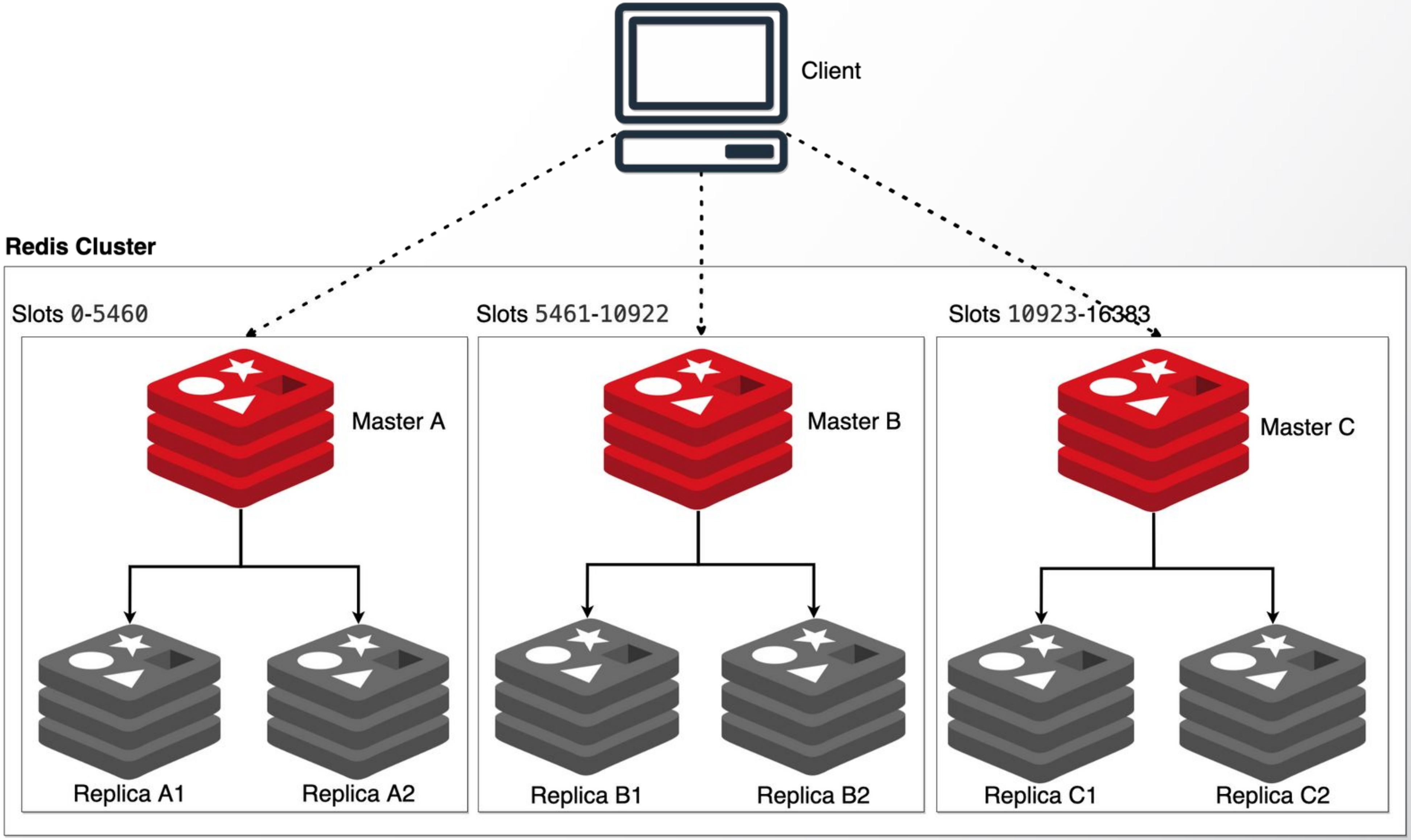
Redis Clustering



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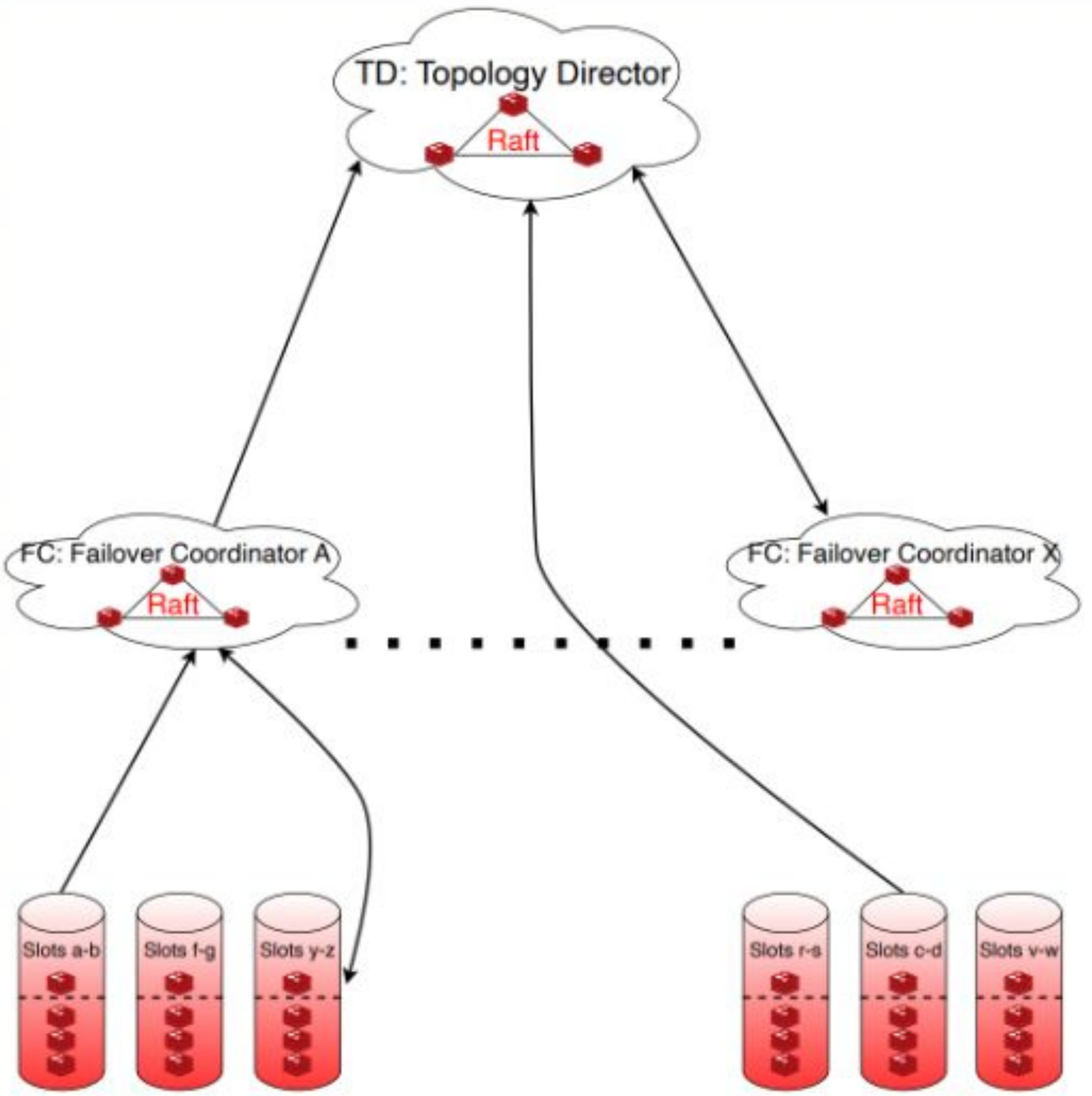
Flotilla - New Redis Cluster

- Two tiers of strongly consistent, consensus-based control plane systems
- Strong Consistency using Raft
- Implemented as a Rust module (of course :))
- Coming soon to Open Source near you



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Thank you

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Macros in Rust

Unleashing the power of Metaprogramming

Yael Tzirulnikov/Software engineer, redis

Introductions

Yael Tzirulnikov

Senior Software Engineer

A Riddle / C.GPT

I’m short and sweet, but can be tricky at times.
I can save you a lot of typing lines.
I help simplify code that’s long and repetitive,
Just call my name, and you’ll be so effusive!
What am I?

A Macro!

Agenda

1. Macros in general
2. Declarative macros
3. Procedural macros
4. Some cool macros

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Macros in general

- Meta programming - code that writes other code
- Can receive a variable number of parameters
- Macros are expanded before the program finishes compiling
- More complexity- hard to read and maintain

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Types of Macros in Rust

Declarative Macros

- `macro_rules!`

Procedural Macros

- `#[proc_macro]`
- `#[proc_macro_derive]`
- `#[proc_macro_attribute]`

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Declarative macros

- Allow you to write something similar to match expression
- Macros also compare a value to patterns that are associated with particular code:
  - the value is the literal Rust source code passed to the macro
  - the patterns are compared with the structure of that source code
  - the code associated with each pattern, when matched, replaces the code passed to the macro

Example- vec!

```
let v: Vec<u32> = vec![1, 2, 3];
```

```
#[macro_export]
macro_rules! vec {
    ( $( $x:expr ),* ) => {
        {
            let mut temp_vec = Vec::new();
            $(
                temp_vec.push($x);
            )*
            temp_vec
        }
    };
}
```

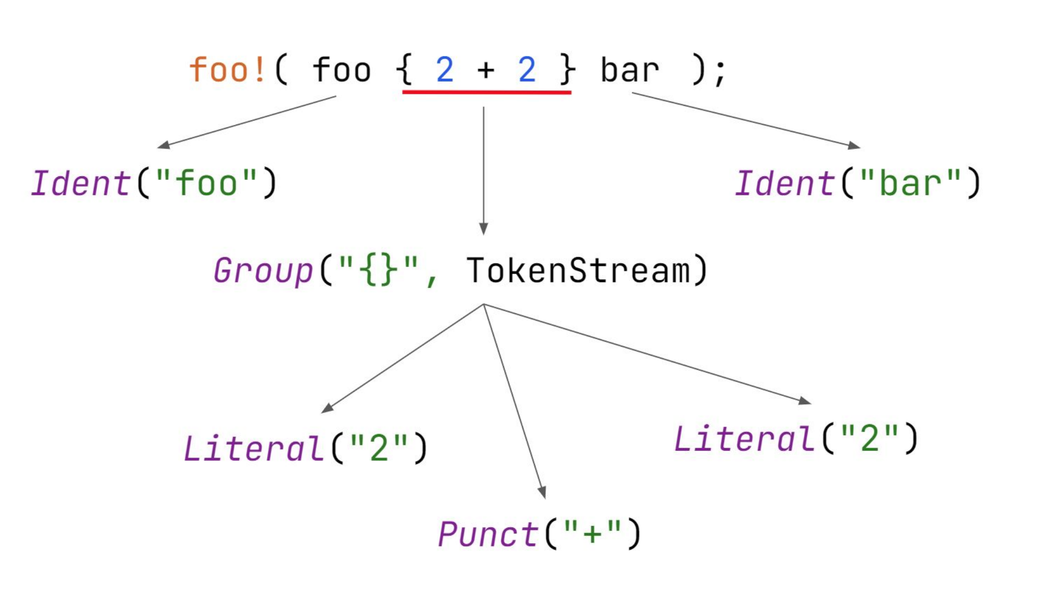
```
{
    let mut temp_vec = Vec::new();
    temp_vec.push(1);
    temp_vec.push(2);
    temp_vec.push(3);
    temp_vec
}
```

Procedural macros

- Act more like functions
- Accept some code as an input, operate on that code, and produce some code as an output

```
use proc_macro;

#[some_attribute]
pub fn some_name(input: TokenStream) -> TokenStream {
}
```



Syn, Quote crates

Syn:
Parse a stream of Rust tokens into a syntax tree of Rust source code

Quote:
Turn Rust syntax tree data structures into tokens of source code

Procedural macros types

- custom derive
- attribute-like
- function-like

Custom derive macros

```
#[derive(serde::Serialize, serde::Deserialize)]
pub struct Module {}
```

- Used on structs and enums
- Specify code **added** with the derive attribute

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Custom derive macro- example

```rust
impl HelloMacro for Pancakes {
    fn hello_macro() {
        println!("Hello, Macro! My name is Pancakes!");
    }
}
```

↓

```rust
#[derive(HelloMacro)]
struct Pancakes;
```

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hello_macro_derive crate

```toml
[package]
name = "hello_macro_derive"
version = "0.1.0"
authors = ["Your Name <you@example.com>"]
edition = "2018"

[lib]
proc-macro = true

[dependencies]
syn = "1.0"
quote = "1.0"
```

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hello_macro_derive implementation

```
extern crate proc_macro;

use proc_macro::TokenStream;
use quote::quote;
use syn;

#[proc_macro_derive(HelloMacro)]
pub fn hello_macro_derive(input: TokenStream) -> TokenStream {
    // Construct a representation of Rust code as a syntax tree
    // that we can manipulate
    let ast : DeriveInput = syn::parse( tokens: input).unwrap();

    // Build the trait implementation
    impl_hello_macro(&ast)
}
```

Syn result

```
DeriveInput {
    // --snip--

    ident: Ident {
        ident: "Pancakes",
        span: #0 bytes(95..103)
    },
    data: Struct(
        DataStruct {
            struct_token: Struct,
            fields: Unit,
            semi_token: Some(
                Semi
            )
        }
    )
}
```

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hello_macro_derive implementation cont.

```
fn impl_hello_macro(ast: &syn::DeriveInput) -> TokenStream {
    let name : &Ident = &ast.ident;
    let gen : TokenStream = quote! {
        impl HelloMacro for #name {
            fn hello_macro() {
                println!("Hello, Macro! My name is {}!", stringify!(#name));
            }
        }
    };
    gen.into()
}
```

The result

```rust
#[derive(HelloMacro)]
struct Pancakes;

fn main() {
    Pancakes::hello_macro();
}
```

Attribute like macros

```
#[route(GET, "/")]
fn index() {
```

- define custom attributes usable on any item
- The returned TokenStream **replaces** the item with an arbitrary number of items.

The signature of the macro definition function would look like this:

```
#[proc_macro_attribute]
pub fn route(attr: TokenStream, item: TokenStream) -> TokenStream {
```

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Function like macros

```
todo_or_die::after_date!(2023, 3, 1);
```

```
let testing = indoc! {"
        def hello():
            print('Hello, world!')

        hello()
    "};
```

- Look like function calls but operate on the specified tokens
- Similar to macro_rules! macros, but much more flexible
- The output TokenStream **replaces** the entire macro invocation.

```
#[proc_macro]
pub fn after_date(input: TokenStream) -> TokenStream {}
```

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Some cool macros

Log-derive- Result logging

https://crates.io/crates/log-derive

```
#[logfn(Err = "Error", fmt = "Failed Sending Packet: {:?}")]
#[logfn_inputs(Info)]
 fn send_hi(addr: SocketAddr) -> Result<(), io::Error> {
     let mut stream = TcpStream::connect(addr)?;
     stream.write(b"Hi!")?;
     Ok( () )
 }
```

A macro to log errors and inputs from a function.

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Some cool macros

Recap- regex parsing

https://crates.io/crates/recap

```
#[recap(regex = r#"(?x)
(?P<foo>\d+)
\s+
(?P<bar>true|false)
\s+
(?P<baz>\S+)
"#)]
struct LogEntry {
    foo: usize,
    bar: bool,
    baz: String,
}
```

An easy way to build data from regex strings!

```
let entry: LogEntry = "1 true hello".parse()?;
```

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Some cool macros

Shrinkwraprs — generate distinct types

https://crates.io/crates/shrinkwraprs

```
#[derive(Shrinkwrap)]
struct Email(String);
```

```
let email = Email("chiya+snacks@natsumeya.jp".into());
let is_discriminated_email =  email.contains("+");  // Woohoo, we can
use the email like a string!
```

Shrinkwraprs redefines a datatype as a new distinct type. You can add the Shrinkwrap attribute to inherit all the behaviour of the embedded datatype.

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Some cool macros

Metered

https://crates.io/crates/metered

This macro will automatically generate the following stats on a method:

- `HitCount`: number of times a piece of code was called
- `ErrorCount`: number of errors returned – (works on any expression returning a Result)
- `InFlight`: number of requests active
- `ResponseTime`: statistics on the duration of an expression
- `Throughput`: how many times an expression is called per second.

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Some cool macros

Metered

```
#[metered(registry = BizMetrics)]
impl Biz {
    #[measure([HitCount, Throughput])]
    pub fn biz(&self) {
        let delay =
std::time::Duration::from_millis(rand::random::<u64>() %
200);
        std::thread::sleep(delay);
    }
}
```

Retrieve the metrics as serialised yaml:

```
let biz = Arc::new(Biz::default());
let serialized =
serde_yaml::to_string(&*biz).unwrap()
;
```


```
metrics:
 biz:
   hit_count: 1000
   throughput:
     - samples: 20
       min: 35
       max: 58
       mean: 49.75
       stdev: 5.146600819958742
       90%ile: 55
       95%ile: 55
       99%ile: 58
       99.9%ile: 58
       99.99%ile: 58
     - ~
```


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Future

There are some strange edge cases with `macro_rules!`.

Macro 2.0 feature is in progress- a second kind of declarative macro

that will work in a similar fashion but fix some of these edge cases.

After that update, `macro_rules!` will be effectively deprecated.

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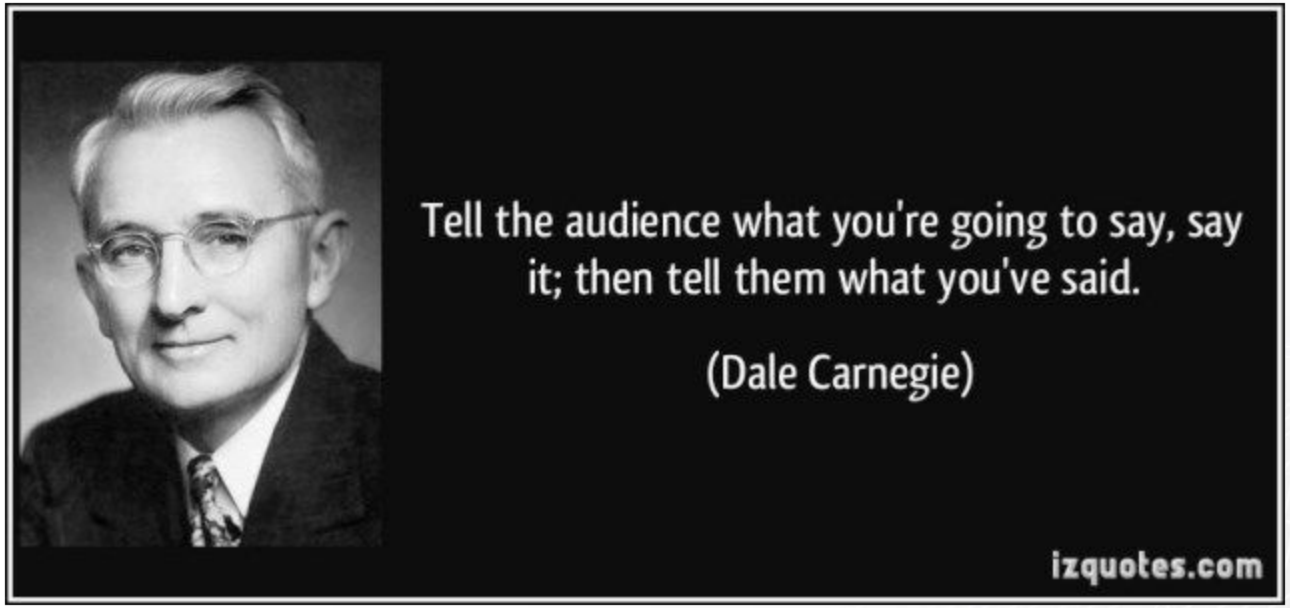
Summary


Tell the audience what you're going to say, say it; then tell them what you've said.
(Dale Carnegie)
izquotes.com

Thank you

Yael Tzirulnikov

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Rust Const Generics

Gil Dafnai, Software Engineer,
Redis

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Introductions

Gil Dafnai

Software Engineer

Agenda

1. Motivation and Intuition
2. General Information
3. Nightly Features
4. References and other sources

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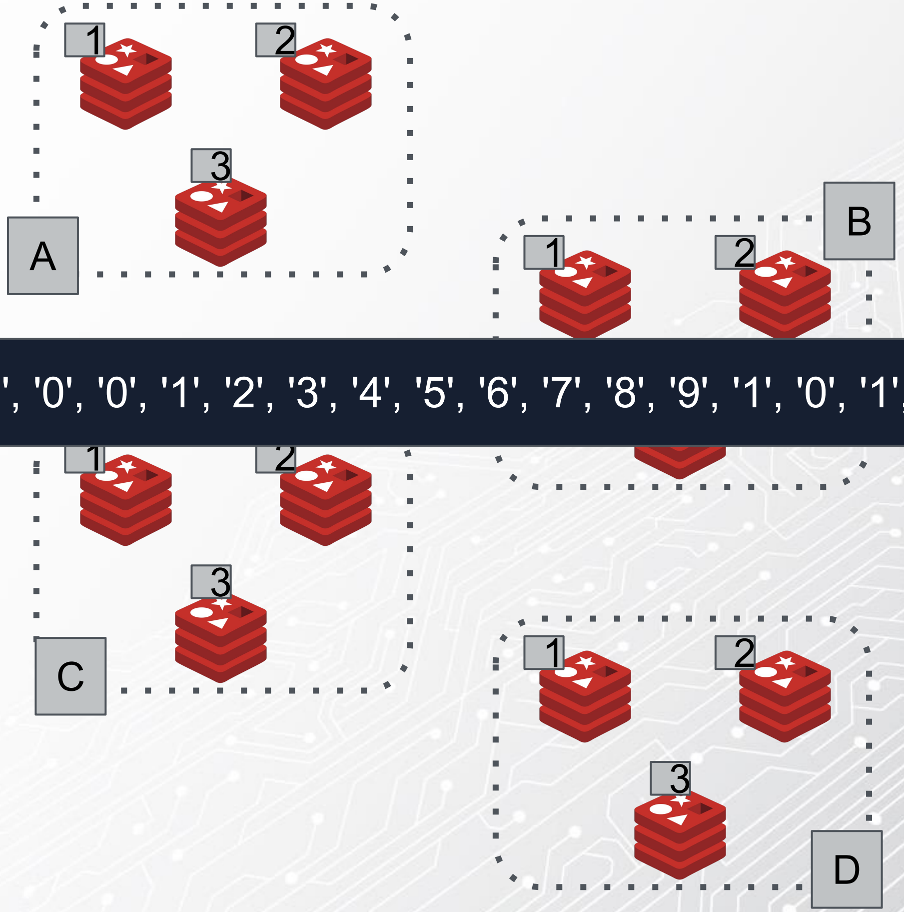
A Real Life (?) Example

```
#[derive(Debug)]
struct ClusterID {
    value: [char; 32],
}
```

'0', '0', '0', '0', '0', '0', '0', '0', '0', '0', '0', '0', '0', '0', '0', '0', '0', '0', '0', '0', '0', '0', '0', '0', '0', '1', '2', '3', '4', '5', '6', '7', '8', '9', '1', '0', '1', '1', '1', '2']

```
struct NodeID{
    value: [char; 40],
}
```



Implementing ID

One implementation for each struct

```
struct ClusterID {
    value: [char; 32],
}

impl Debug for ClusterID {
    ...
}
```

```
struct NodeID{
    value: [char; 40],
}

impl Debug for NodeID {
    ...
}
```

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Implementing ID

Parameterize the Length

- We are just Moving the problem to run time.

```
struct ID(Vec<char>, usize)
```

```
struct ClusterID {
    value: ID,
}
impl ClusterID {
    const LENGTH: usize = 32
}

struct NodeID {
    value: ID,
}
impl NodeID {
    const LENGTH: usize = 40
}
```

if you have the time go read
Why Static Languages Suffer From Complexity
Great comparison of applying static and dynamic patterns to the same problem

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Implementing ID

Parameterize the Length

- Vector allow us to parameterized the Length - but at run time
- We want it at compile time!
- Just like ***Vec<String> != Vec<u32>*** we should be able to say to ***ID<8> != ID<10>*** (but both are still IDs)

Implementing ID

Use Const Generics

- An ID can still be an array of any length. But it has to be a specific one.
- We can now implement Debug (or any trait) for any ID.

```
struct ID<const LEN: usize>([char; LEN])

struct ClusterID {
    value: ID<32>,
}

struct NodeID {
    value: ID<40>,
}
```

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Const Generics

General Information

- ***Const generics are generic arguments that range over constant values, rather than types or lifetimes.***
- This allows, for instance, types to be parameterized by integers.
- Arrays already allow specifying their length ([T; N]) but not in a generic way (think about trying to implement a trait for an array of specific length)

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Const Generics

General Information

- Const Generics were stabilized and released in version 1.51 and are currently in MVP
- Only Integral types are supported - Signed and Unsigned integers, char and bool.
  - So this is used mostly for generalizing arrays
- There are still important features under development

Const Generics

Another example from standard library - *array_chuncks*

- Now you can specify the chunk size. And the chunk size if part of the iterator type.
- There is also a similar function for iterator chunks (the example here is for slices)

```
pub fn array_chunks<const N: usize>(&self) -> ArrayChunks<'_, T, N> {
    ...
}
```

```
// array_chunks
let slice = ['l', 'o', 'r', 'e', 'm'];
let mut iter = slice.array_chunks();
assert_eq!(iter.next().unwrap(), &['l',
'o']);
assert_eq!(iter.next().unwrap(), &['r',
'e']);
assert!(iter.next().is_none());
assert_eq!(iter.remainder(), &['m']);
```

```
// chunks (old, not typed)
let slice = ['l', 'o', 'r', 'e', 'm'];
let mut iter = slice.chunks(2);
assert_eq!(iter.next().unwrap(), &['l',
'o']);
assert_eq!(iter.next().unwrap(), &['r',
'e']);
assert_eq!(iter.next().unwrap(), &['m']);
assert!(iter.next().is_none());
```

MinSlice<T,N>

Performance Improvements

- MinSlice is a slice with know minimal size .
- Just like slice it is unsized
- It allows the compiler to verify access to array items without runtime validation

```
pub struct MinSlice<T, const N: usize>
{

    pub head: [T; N],

    pub tail: [T],
}
```

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MinSlice<T,N>

Performance Implications

```
let slice: &[u8] = b"Hello, world";
let value: Option<&u8> = slice.get(6);
assert!(value.is_some());
```

- but the compiler can't know that ***value*** is a valid reference

```
let slice: &[u8] = b"Hello, world";
let minslice = MinSlice::<u8, 12>::from_slice(
                slice).unwrap();
let value: u8 = minslice.head[6];
assert_eq!(value, b' ')
```

- Length check is performed when we construct a MinSlice
- If the `unwrap()` succeeds, no more checks are needed

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Const Generics

Complex Expressions (Nightly Only)

```
fn foo<const N: usize>(arr: [char; N]) -> [char; N + 1] {
    ...
}
```

```
struct Grid<T, const W: usize, const H: usize> {
    array: [T; W * H],
}
```

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Const Generics

Compile Time Validations (Nightly Only)

- The compiler will prevent runtime errors at compile time
- This specific example is event more powerful when you think about compiling for different platforms and architecture. environments, architectures, etc…

```
pub fn fill_array(number: u64, array: &mut [char]) {
    ... // write number into array and pad with zeros
}

pub fn build_array<const LENGTH: usize>(number: u64) -> [char; LENGTH]
where
    [(); LENGTH - 16]:,
{
    let mut array = ['0'; LENGTH];
    fill_array(number, &mut array);
    return array;
}
```

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Const Generics

More Sources and Examples

- StaticVec - fixed-capacity stack-allocated Vec.
    - also implemented a ***StaticString*** struct (***StaticVec<u8, N>***)
- Implementing Sha2 with Const Generics

```
pub struct Hash<T, const BLOCKSIZE: usize, const ROUNDS: usize> {
    pub k_constants: [T; ROUNDS], // ROUNDS = 64 or 80
    pub hash: [T; 8],
    pub scramble_funcs: ScramblePool<T>, // scrambling functions sigma etc
    pub block: [u8; BLOCKSIZE],          // BLOCKSIZE = 64 or 128
}
```

Const Generics

More Sources and Examples

```
#![feature(adt_const_params)]
#![allow(incomplete_features)]

#[derive(PartialEq, Eq)]
pub enum State {
    Init,
    Accumulate,
    Freeze,
}

pub struct Machine<const S: State> {
    total: u32
}
```

Implementing a [StateMachine]

based on *Const Generics*

```
impl Machine<{State::Init}> {
    pub fn new() -> Self {
        Self {
            total: 0
        }
    }

    pub fn accumulate(self) -> Machine<{State::Accumulate}> {
        Machine {
            total: self.total
        }
    }
}

impl Machine<{State::Accumulate}> {
    pub fn add(&mut self, add: u32) {
        self.total += add
    }

    pub fn freeze(self) -> Machine<{State::Freeze}> {
        Machine {
            total: self.total
        }
    }
}

impl Machine<{State::Freeze}> {
    pub fn unwrap(self) -> u32 {
        self.total
    }
}
```

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Thank you

Gil Dafnai

FFI - How C & Rust can be BFFs?

Sharon Rosenfeld/Principal Software Engineer, redis

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Introductions

Sharon Rosenfeld

Principal Software Engineer

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Agenda

1. Our FFI Use Case
2. 1st phase - basic wrapping
3. 2nd phase - idiomatic wrapping
4. The callback challenge

Our use case

- We write a redis module in Rust
- We needed a Raft Client for our module
- Raft Lib is written in C :(

1st Phase - Basic Wrapping

- BindGen
- OSS tool that consumes C/C++ headers and **generates** Rust FFI bindings
  https://github.com/rust-lang/rust-bindgen

Bindgen Output

Doggo.h

```c
typedef struct Doggo {
    int many;
    char wow;
} Doggo;


void eleven_out_of_ten_majestic_af(Doggo*
pupper);
```

Doggo.rs

```rust
/* automatically generated by rust-bindgen*/
#[repr(C)]
pub struct Doggo {
  pub many: ::std::os::raw::c_int,
  pub wow: ::std::os::raw::c_char,
}
extern "C" {
    pub fn
eleven_out_of_ten_majestic_af(pupper: *mut
Doggo);
}
```

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2nd Phase - Idiomatic Wrapping

- Wrapper Layer
- Idiomatic standardization
  - Return type
  - Simple Arguments
  - Struct Arguments

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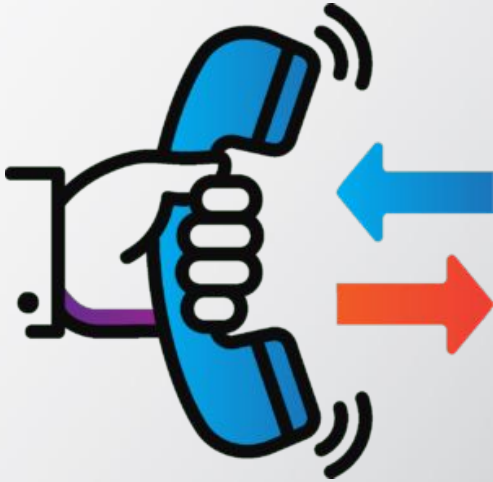
Wrapper Function Example

```
pub fn recv_snapshot_response(
    &self,
    id: RaftNodeId,
    resp: &RaftSnapshotResponse,
) -> Result<(), RaftError> {
    let mut raw_resp: raft_snapshot_resp_t = resp.into();
    let res = unsafe {
        bindings::raft_recv_snapshot_response(
            id,
            &mut raw_resp as *mut raft_snapshot_resp_t,
        )
    };
```

The Callback Challenge

```
extern "C" {
    pub fn raft_recv_read_request(
        cb: raft_read_request_callback_f,
        cb_arg: *mut ::std::os::raw::c_void,
    ) -> ::std::os::raw::c_int;
}
```



```
pub type raft_read_request_callback_f = ::std::option::Option<
    unsafe extern "C" fn(arg: *mut ::std::os::raw::c_void, can_read:
::std::os::raw::c_int),
>;
```

Callback Flow

Application

passes a boxed CB struct

Wrapper

passes predefined CB + the “CB object” from app.

Binding

C Library

Wrapper callback

Unfold the opaque context and call application callback

Application callback

Wrapper Function

```
pub fn recv_read_request<C>(&self, read_ctx: Box<C>) -> Result<(), RaftError>
Where       C: ReadCBCtx,
{
      let ctx_box_ptr = Box::into_raw(read_ctx);
      let ctx_ptr = unsafe { transmute(ctx_box_ptr) };
      let res = unsafe {
         bindings::raft_recv_read_request(
              self.inner,
              Some(callbacks::read_request_callback::<C>),
              ctx_ptr,
         )
    };
```

coldfusion

Wrapper Callback Code

```
pub unsafe extern "C" fn read_request_callback<C>(arg: *mut c_void, can_read:
c_int)
Where C: ReadCBCtx,
{
    let ptr = arg as *mut C;
    let ctx = Box::from_raw(ptr);
    if !can_read {
      ctx.read(Err(EzError::ReadTimeout));
     } else {
      ctx.read(Ok(self.state));
     }
```

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To Wrap Things Up …

- Bindgen
- Turning binding code to beautiful rust code
- Passing objects between rust , c and rust

Thank you

Sharon Rosenfeld

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