ICU4X 1.0: Bringing Internationalization to Rust and Beyond

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Presenter Introduction

Shane F. Carr

Shane is the chair of the ICU4X subcommittee in the Unicode Consortium and lead for Google's efforts to build next-generation internationalization solutions. Shane is also chair of the ECMA-402 task group for ECMAScript internationalization.

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Internationalization

What is i18n and why is it important?

INTERNATIONALIZATION

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

I18N

i18n Is More Than Globalization

Non-English Languages in the U.S.

In 2019, approximately 78% **(241 million)** of all 308.8 million people ages five and older reported speaking only English at home regardless of their nativity. The remaining 22% **(67.8 million)** reported speaking a language other than English at home.

Based on this data, Mandarin and Cantonese were the most common non-English, non-Spanish languages spoken in the U.S., with more than **3.4 million** speakers across the country.

Here is a list of the most common languages spoken at home in the U.S., outside of English:

Language	Population Estimate	Share of Foreign Language Speakers
Spanish	41,757,000	61.6%
Cantonese and Mandarin	3,495,000	5.2%
Tagalog	1,764,000	2.6%
Vietnamese	1,571,000	2.3%
Arabic	1,260,000	1.9%
French and Louisiana French	1,172,000	1.7%
Korean	1,075,000	1.6%
Russian	941,000	1.4%
Haitian Creole	925,000	1.4%
German	895,000	1.3%

i18n Is More Than Translation

Are the lights currently “on” or “off” at this office in Japan?

i18n Is Deep

- Every language, region, and culture has its own unique challenges
- What works for one locale may not work for another
- Always use official i18n solutions

Evolving Needs for International Software

- More Users in More Languages
- Smaller Devices
- Client-Side / Edge Computing

ICU4X Overview

How did the project come about?

What are the goals?

ICU4X is a modular internationalization library in Rust

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- ICU = International Components for Unicode
- ICU4J & ICU4C (aka libicu) are industry standards, also maintained by Google i18n and others

ICU4X is a modular internationalization library in Rust

- Formatting of dates, times, and numbers
- Grammatical feature selection (plurals)
- Unicode text processing (properties, segmentation, collation)
- Time zones & non-gregorian calendars
- ...and more!

ICU4X is a modular internationalization library in Rust

- Small code size & low memory usage
- Only include what you need
- Pluggable data
- Usable on embedded systems!

ICU4X is a modular internationalization library in Rust

- Extensible FFI support via Diplomat
- C++, C, and TypeScript/JS/WASM APIs
- Future: Dart, Java, ..?

ICU4X is a modular internationalization library in Rust

- Safe by default
- Blazing fast zero-copy deserialization
- But usable from other languages!
- Benefit from Rust's ecosystem

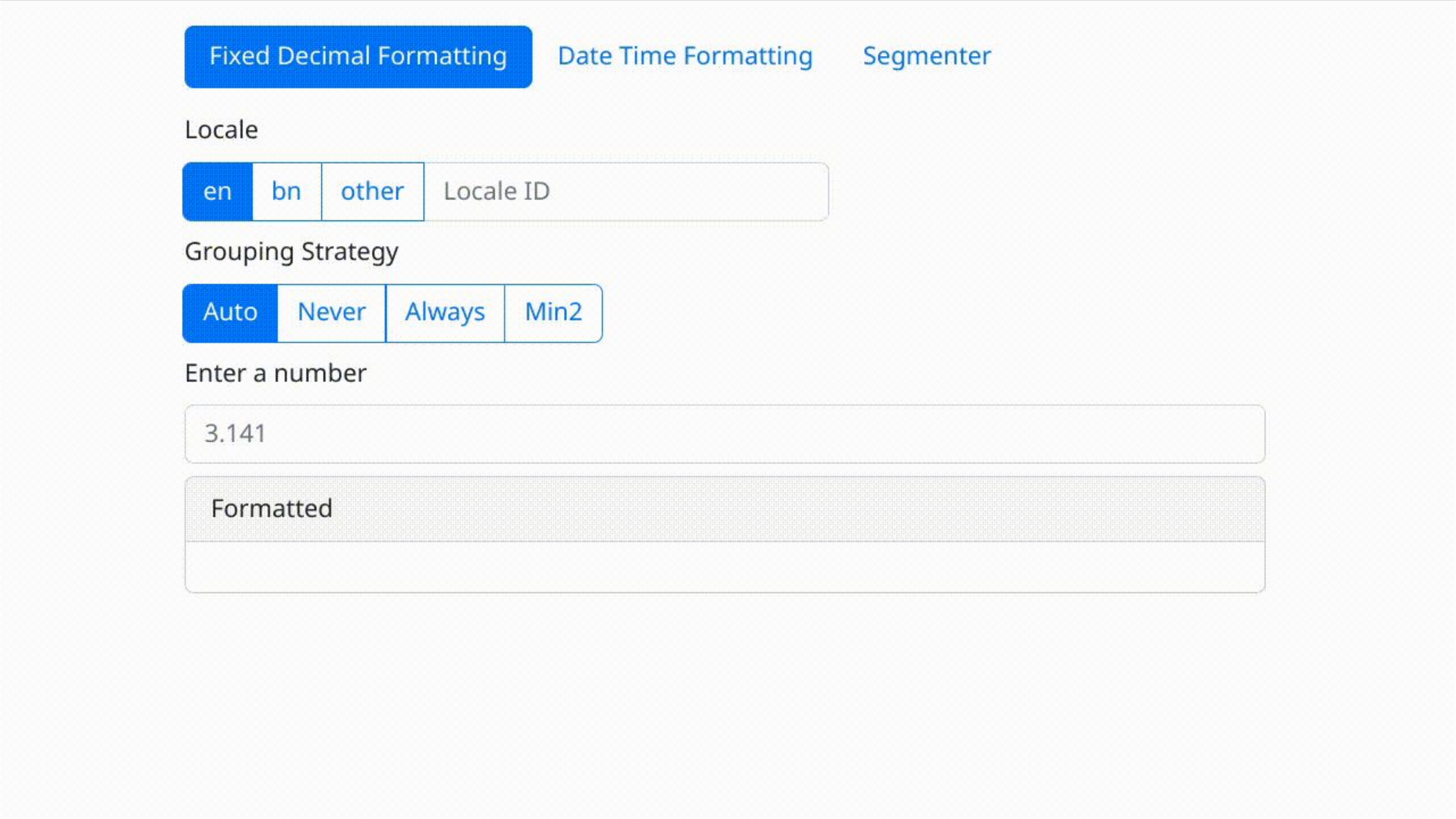
Key Value Proposition

ICU4X is:

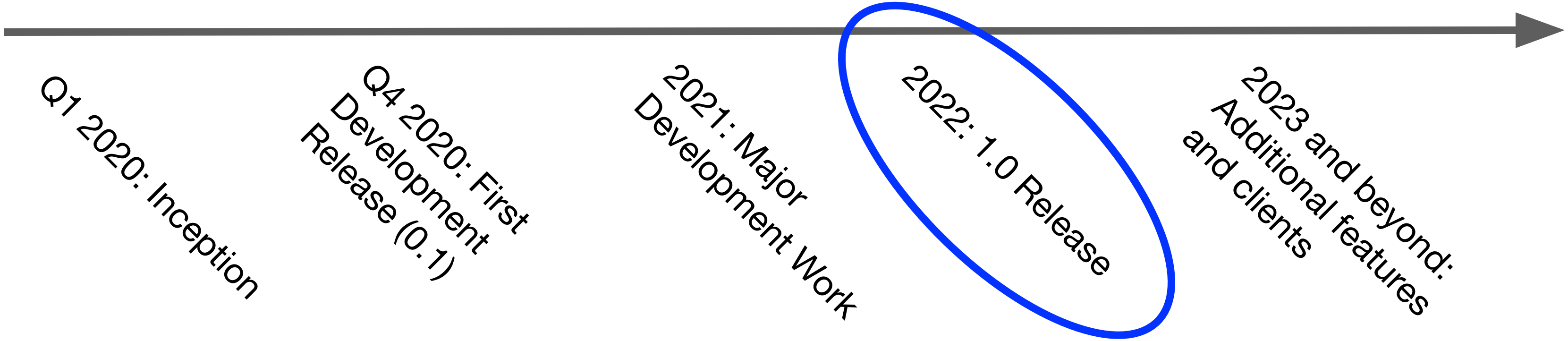
- ❖ Lightweight
- ❖ Portable
- ❖ Secure

Who are we?

ICU4X WebAssembly Demo



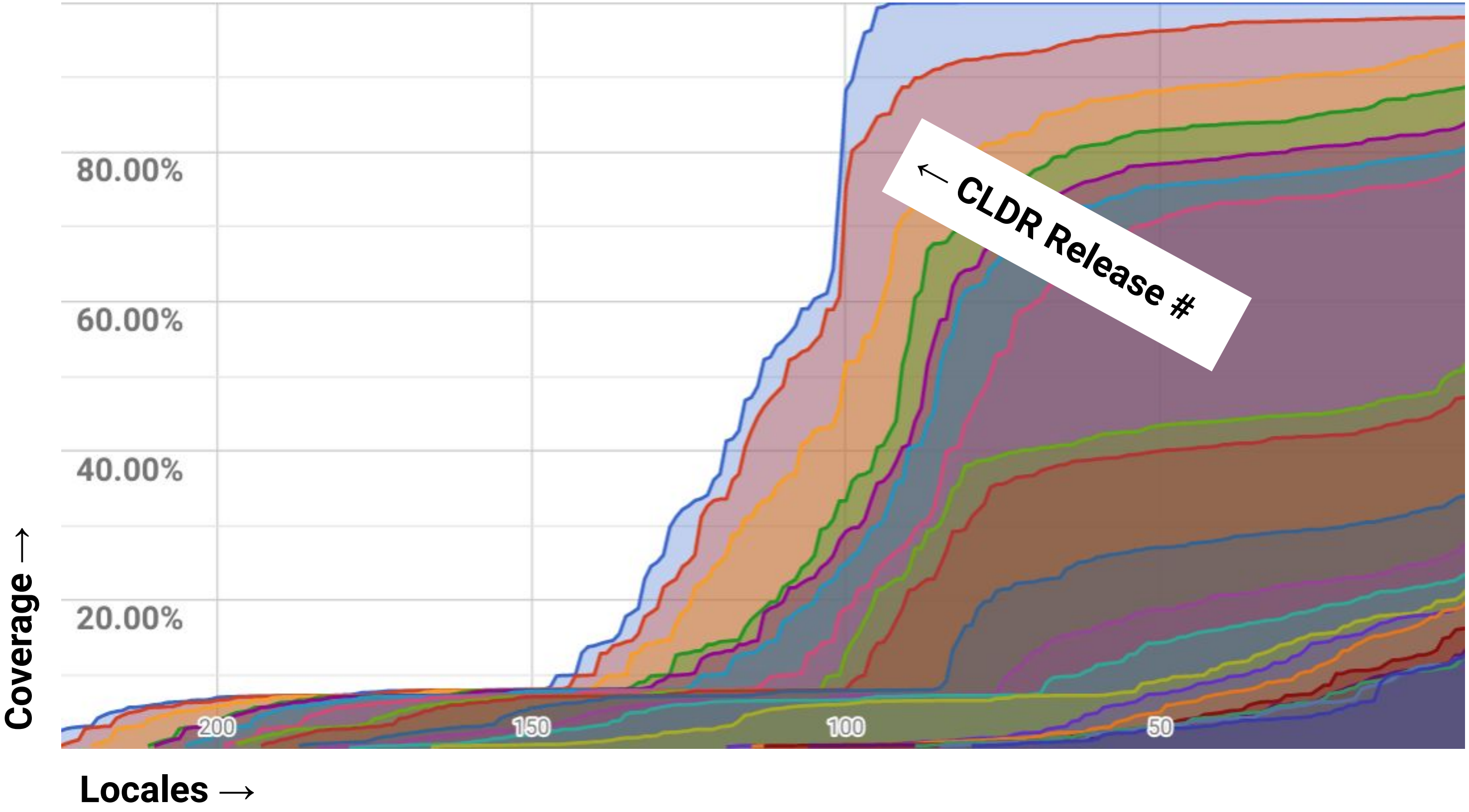
ICU4X Project Status



Data Management

How ICU4X is, at its core, a pipeline
for locale data.

Common Locale Data Repository (CLDR)



Locale Data Is Challenging

- Locale data is Big
  - Quadratic growth:
    # of features * # of locales
- Locale data is Heterogeneous
  - Every piece of data is different
- Locale data is Algorithm-Heavy
  - Need complex code to process it

Multi-Pronged Approach

1
Zero Copy
No memory allocations

2
Stable Files
Backward and forward compatible

3
Pluggable Pipeline
Multiple data sources & overlays

4
Dynamic Loading
Download on demand

5
Static Slicing
Pay for what you use

6
Live Refresh
Unload data without app restart

Modularity

How did we make ICU4X lightweight?

Optimizing for Tree Shaking and Code Size

- Smaller crates
  - Makes dependencies more explicit
- Smaller functions
  - Avoid large conditional code paths that could be dead-code eliminated
- Make error types Copy
  - Eliminates invocations of Drop
- Use traits wisely
  - Generics duplicate code
  - Trait objects (*dyn*) hard to optimize
  - Solution: use generics for APIs and delegate into a single low-level fn

Static Analysis for Data Slicing

- **Annotate fns with data requirements**
- **Explicit data provider argument**
- **Analyze DCE'd code for data it needs**
  - Build optimal data files

```rust
impl TimeFormatter {

pub fn try_new_with_length_unstable<D>(
    data_provider: &D,
    locale: &DataLocale,
    length: Time
) -> Result<TimeFormatter, DateTimeError>
where
    D: DataProvider<TimeLengthsV1Marker> +
       DataProvider<TimeSymbolsV1Marker> +
       DataProvider<DecimalSymbolsV1Marker> +
       ?Sized,
```

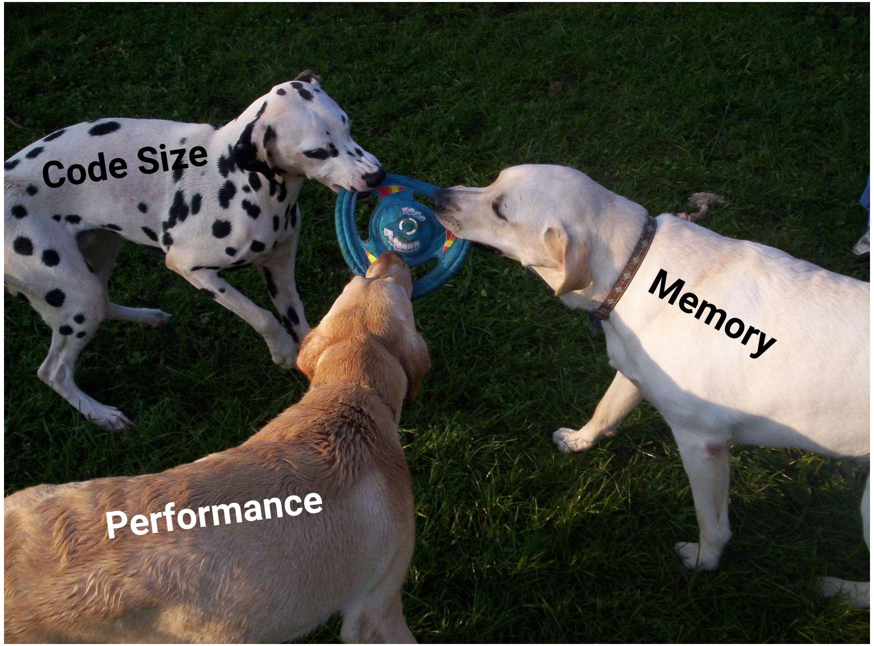
Only these 3 data impls get linked!

Postcard and zero-copy deserialization

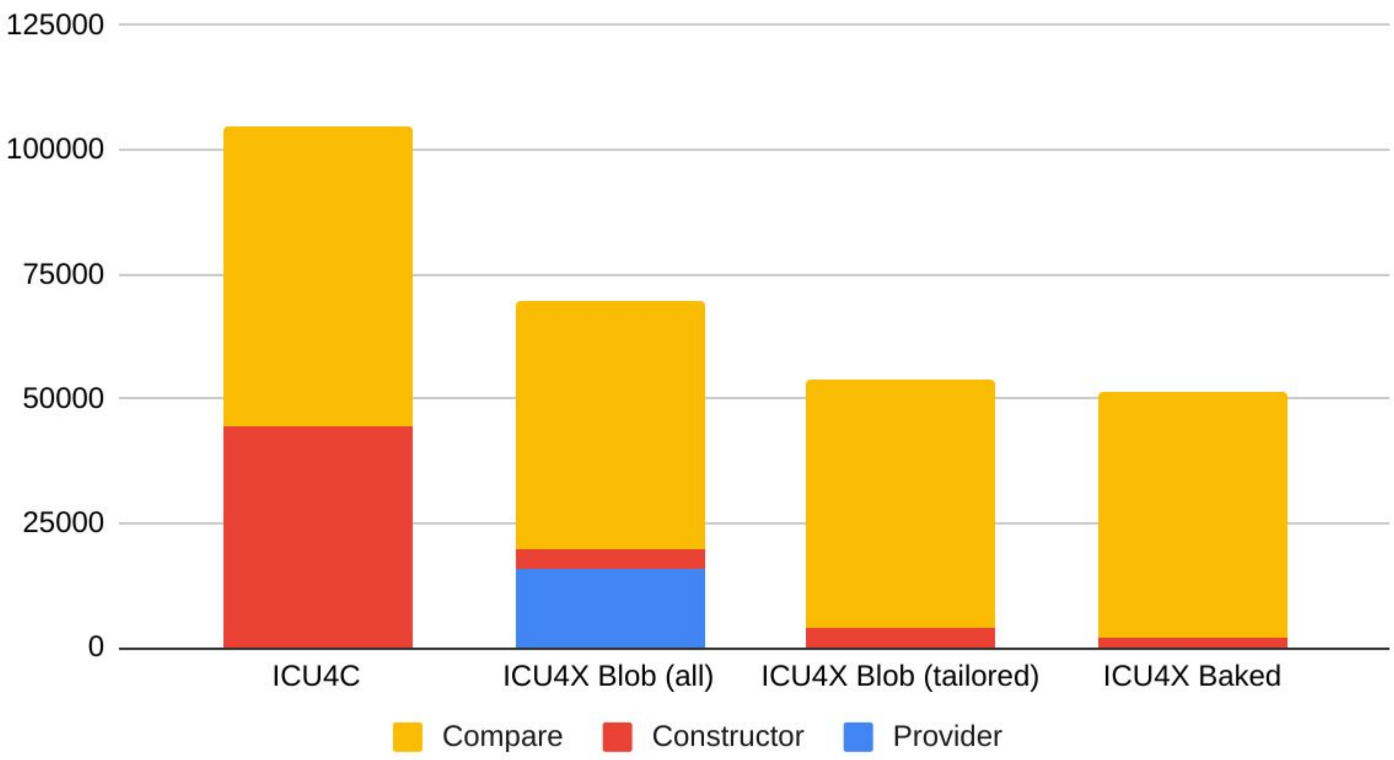
- ICU4X supports dynamically loaded data
  - Download more locales when needed
  - Load from the environment or OS
- The data needs to be serialized for interchange
- But normally, deserialization is expensive!
  - Slow, lots of memory, lots of code
- Enter Postcard with ZeroVec
  - Zero-copy deserialization with small code and no memory allocations!
  - #[no_std] compatible
  - More on ZeroVec later!

Balancing Performance

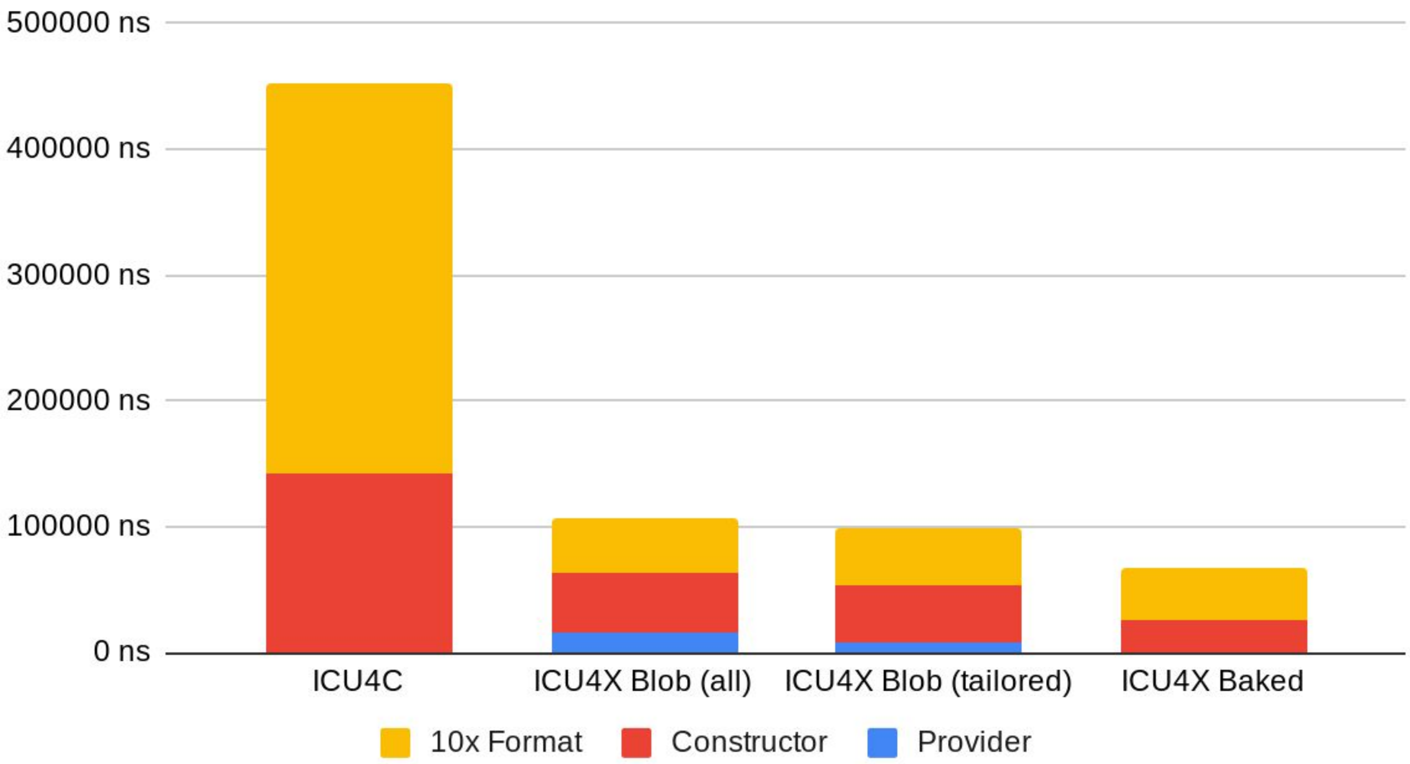
- Sometimes, changes that improve performance also reduce memory and code size
  - Example: zero-copy deserialization
- But, sometimes the goals compete
  - Example: binary search vs hash table
- ICU4X tries to take a holistic view: big wins on one metric could come at smaller losses on another
  - Example: character properties



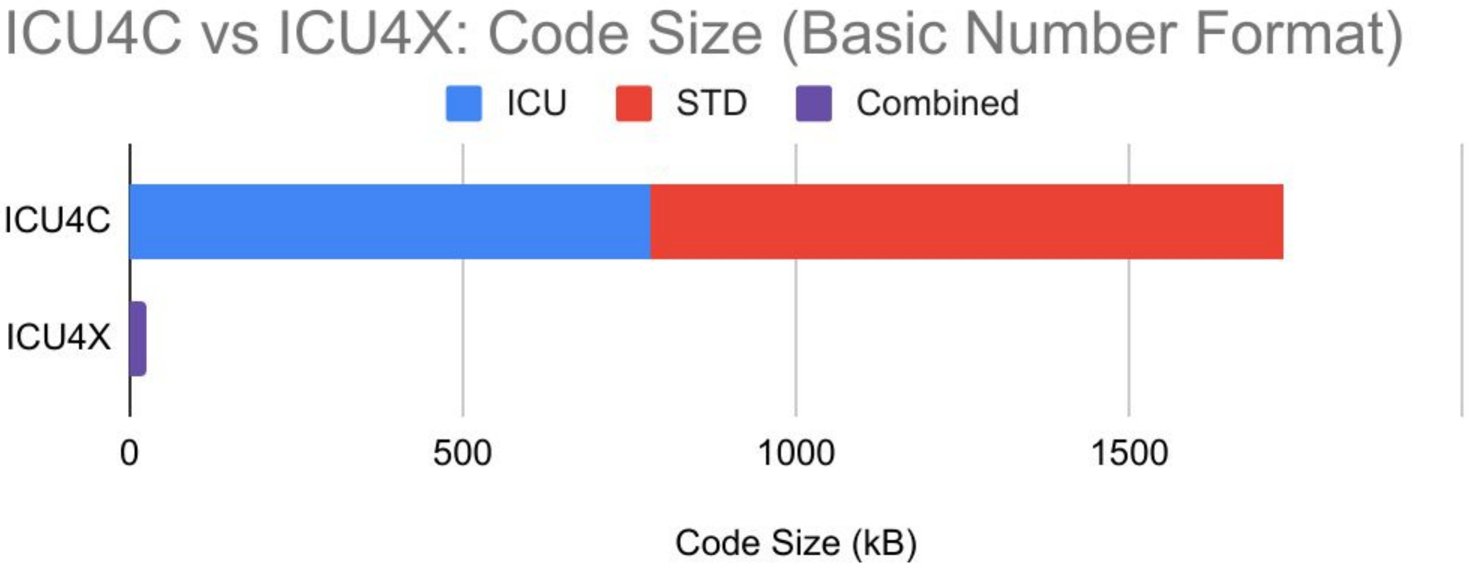
ICU4C 72 vs ICU4X 1.0 PluralRules



ICU4C 72 vs ICU4X 1.0 DateTimeFormatter



Code size for program that prints 1,000,007 in Bangla digits: "১০,০০,০০৭"



Learnings

What can be learned from building a core library for the Rust ecosystem?

no_std*

- Abstract data storage when possible
  - Example: Filesystem data provider
- Embedded Devices
  - Internet-of-Things, etc.
- Good for WASM and portability
  - Fewer dependencies when linking ICU4X
  - Easier and smaller when built to WASM
- * But you require the alloc module?
  - ICU4X is designed such that we can fully remove runtime allocations if necessary. Interested in a fully no-alloc ICU4X? Let us know!

Deliberate Dependencies

- cargo tree in icu metacrate has almost 200 lines?! 🧐
- However, most deps are:
  - Duplicates (lots of those)
  - Sub-components of ICU4X
  - Unsafe utilities
  - Build-time deps
- tl;dr, Small crates are good, but they make dependencies look bigger than they really are

```
│   ├── tinystr v0.6.2 (/usr/local/googl
│   ├── writeable v0.4.1 (/usr/local/goo
│   └── zerovec v0.8.1 (/usr/local/googl
├── icu_collator v1.0.0-beta1 (/usr/loca
│   ├── displaydoc v0.2.3 (proc-macro) (
│   ├── icu_collections v1.0.0-beta1 (/u
│   │   ├── displaydoc v0.2.3 (proc-macr
│   │   ├── yoke v0.6.1 (/usr/local/goog
│   │   ├── zerofrom v0.1.1 (/usr/local/
│   │   └── zerovec v0.8.1 (/usr/local/g
│   ├── icu_locid v1.0.0-beta1 (/usr/loc
│   ├── icu_normalizer v1.0.0-beta1 (/us
│   │   ├── displaydoc v0.2.3 (proc-macr
│   │   ├── icu_collections v1.0.0-beta1
│   │   ├── icu_properties v1.0.0-beta1
│   │   │   ├── displaydoc v0.2.3 (proc-
│   │   │   ├── icu_collections v1.0.0-b
│   │   │   ├── icu_provider v1.0.0-beta
│   │   │   └── zerovec v0.8.1 (/usr/loc
│   │   ├── icu_provider v1.0.0-beta1 (/
│   │   ├── smallvec v1.9.0
│   │   ├── utf16_iter v1.0.3
│   │   ├── utf8_iter v1.0.3
│   │   ├── write16 v1.0.0
```

Be Friendly

- No implicit panics
  - Clippy-enforced checks:
    - indexing_slicing
    - unwrap_used
    - …
- Data-driven algorithms increase the potential error space
  - Validate when it's cheap
  - When it's expensive: log::warn, debug_assert, and/or best effort (handle errors gracefully)

Closing Thoughts

Key Takeaways

★ i18n consists of subtle, data-driven algorithms

★ Use ICU4X for your i18n needs in Rust and beyond

★ You can build a large library that is no_std, doesn't panic, and remains suitable for slicing and other compiler optimizations

Thank you for your time!

icu4x.unicode.org