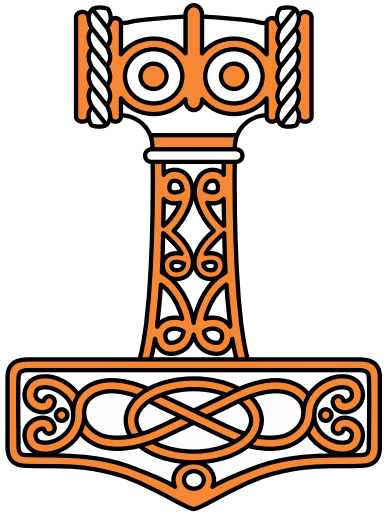

DYALOG

Stuttgart, November 2022

# The Road Ahead



*Morten Kromberg*

# Ten Lane Highway

1. Building the Team
2. Training & Evangelism
3. Consulting
4. Source in Text Files
5. Service Orientation
6. Cross-Platform UI
7. [Microsoft].NET
8. New Target Platforms
9. Compiling APL
10. APL Language

# 1. [Re]Building the Team

- We stand upon the shoulders of Giants

John Scholes (1948-2019)

Roger Hui (1953-2021)

# Still Going Strong...

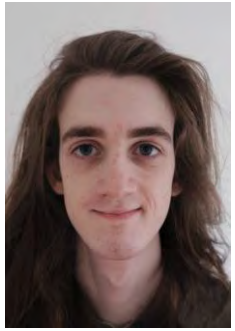
- With John Scholes, Geoff Streeter wrote Dyalog APL v1.0 in 1981-1983
- Geoff is in good health
  - Now working 3 days per week
  - And still volunteering at night...
- However, Geoff has announced that he intends to retire in April'23
- We hope to welcome him back for a retrospective talk at Dyalog'23

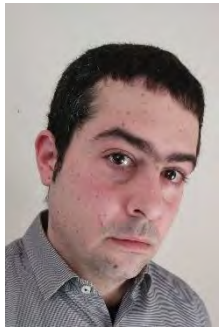
# Dyalog … The Next Generation





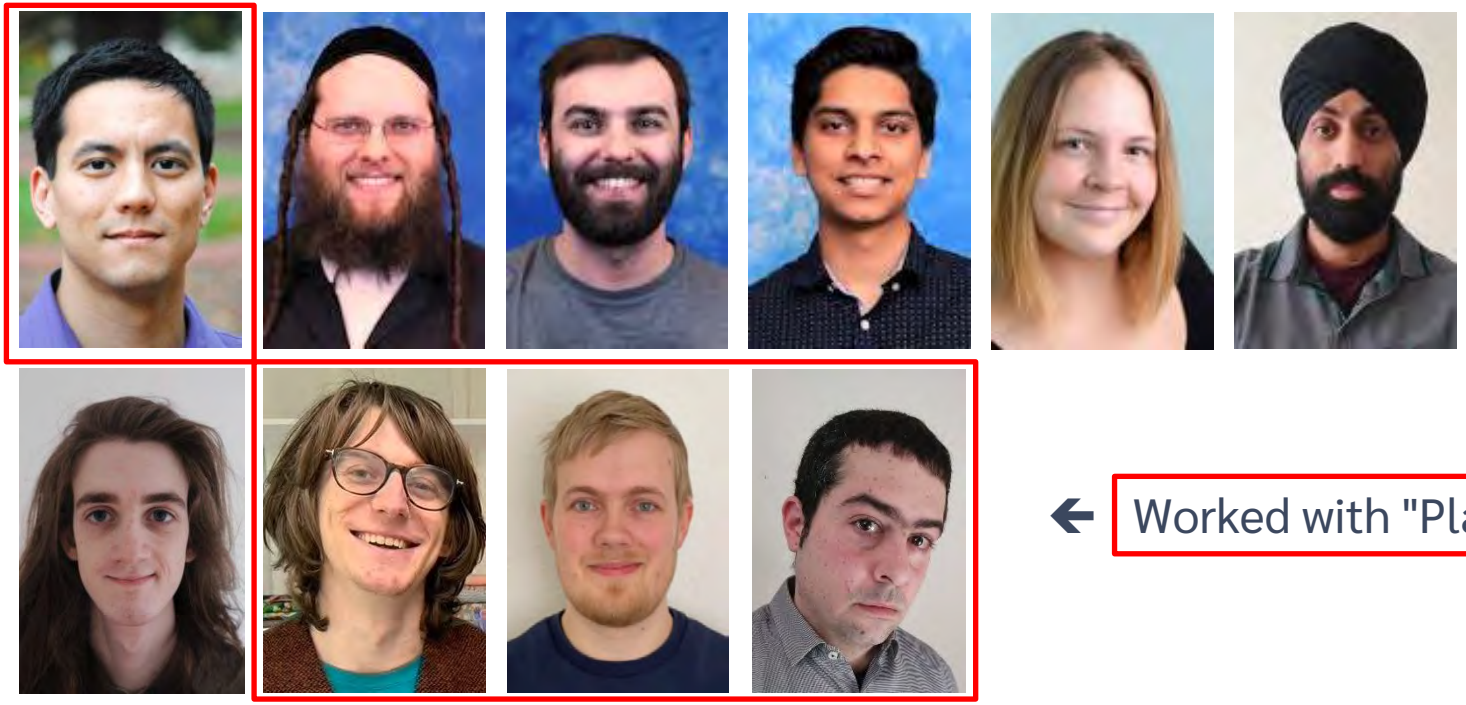




← February, May, July & September 2022

# Dyalog … The Next Generation



← Worked with "Plan 9"


Sun Jun 11 12:45

| rsc | /dev/n | jmk | skipt | tklopp | john | brucee | lorenz |
|---|---|---|---|---|---|---|---|
| 12:17 | 11:47 | 11:16 | 02:50 | 02:05 | 02:03 | Jun 10 | Jun 10 |

olive(4) anna achille

load con

Mail Newcol Kill Putall Dump Exit

New Cut Paste Snarf Sort Zerox Delcol

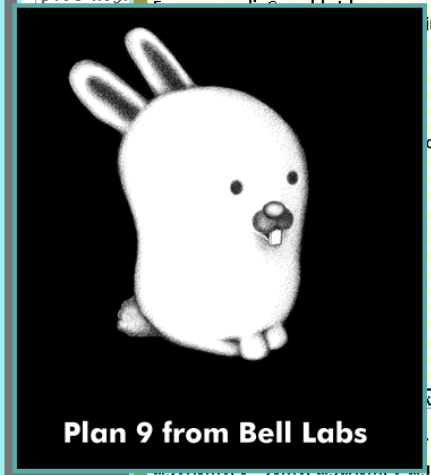
/mail/fs/mbox/34/ Del Snarf | Look Reply all Delmesg Save

===> 3/ (multipart/mixed) [inline]

%g scat
ori
638 items
plot nogr

imk@plan9.bell-labs.com rsc@plan9.bel

ody.jpg /usr/rob/plan9bunnysm.jpg




New Cut Paste Snarf Sort Zerox Delcol

/acme/mail/guide Del Snarf | Look

Mail stored
plumb /mail/box/$user/names
mail -'x' someaddress
mkbox /mail/box/$user/new_box

/mail/fs/mbox/ Del Snarf | Look Put Mail

34/ Russ Cox <rsc@plan9.bell-labs.com> Su
n 11 Jun 12:17
34/1/ (text/plain)
34/2/ rob pike <rob> (text/plain)
34/3/ renee french <cornelia@world.st
d.com>
34/3/1/ (text/plain)
34/3/2/ (image/jpeg)
34/3/3/ (text/plain)
33/ /dev/null Sun 11 Jun 11:47
32/ jmk Sun 11 Jun 11:16
32/1/ (text/plain)
32/2/ DAGwyn@aol.com (text/pl

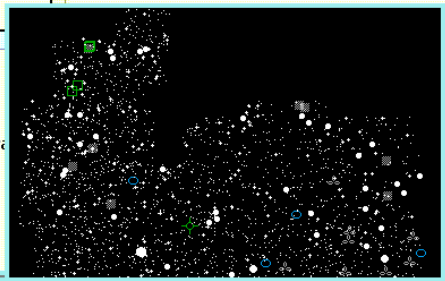
/usr/rob/lib/plumbing Del Snarf | Look

# to update: cp /usr/$user/lib/plumbing /mnt/
plumb/rules

editor = acme

3–6 augrim, 4 –ym, 5 –ime,
–ime, 7 agrum, algrim. β. 4–6
garosme, aulgorism(e, augrisme,
7–9 algorism, algorithm. [a. OFr. augorisme, algorisme, augorime;
ad. med.L. algorism–us (cf. Sp. guarismo cipher), f. Arab. al–Khowārā
the native of Khwārazm (Khiva), surname of the Arab mathematician
Abu Ja'far Mohammed Ben Musa, who flourished early in the 9th
c., and through the translation of whose work on Algebra, the
Arabic numerals became generally known in Europe. (Cf. 'Euclid'
= plane geometry.) Algorisme being popularly reduced in OFr.
to augorime, English also shows two forms, the popular augrime,
ending in agrim, agrum, and the learned algorism which passed

window
x
x.gif
y
日本語
%g ech
%g

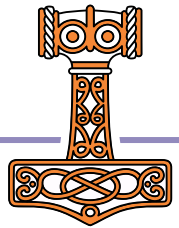


# Software Security Process

Building Security in Maturity Model

BSIMM

- Compare own routines to industry practices
- Implement and continuously review practices that reduce security risk
  - Dyalog's processes will treat potential **computational errors** as threats on par with **classical security threats**
- Hope to publish an Audit Report in ~~2022~~2023



# 1. Building the Team

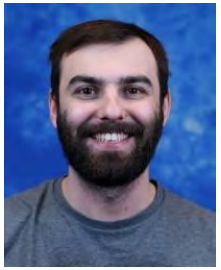
**Talks by recent recruits...**

**D06** APL9 from Outer Space
(Peter Mikkelsen)

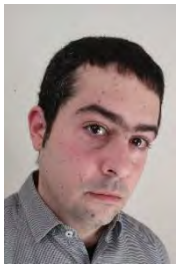
**D09** Performance Improvements in Set Operations
(Karta Kooner)

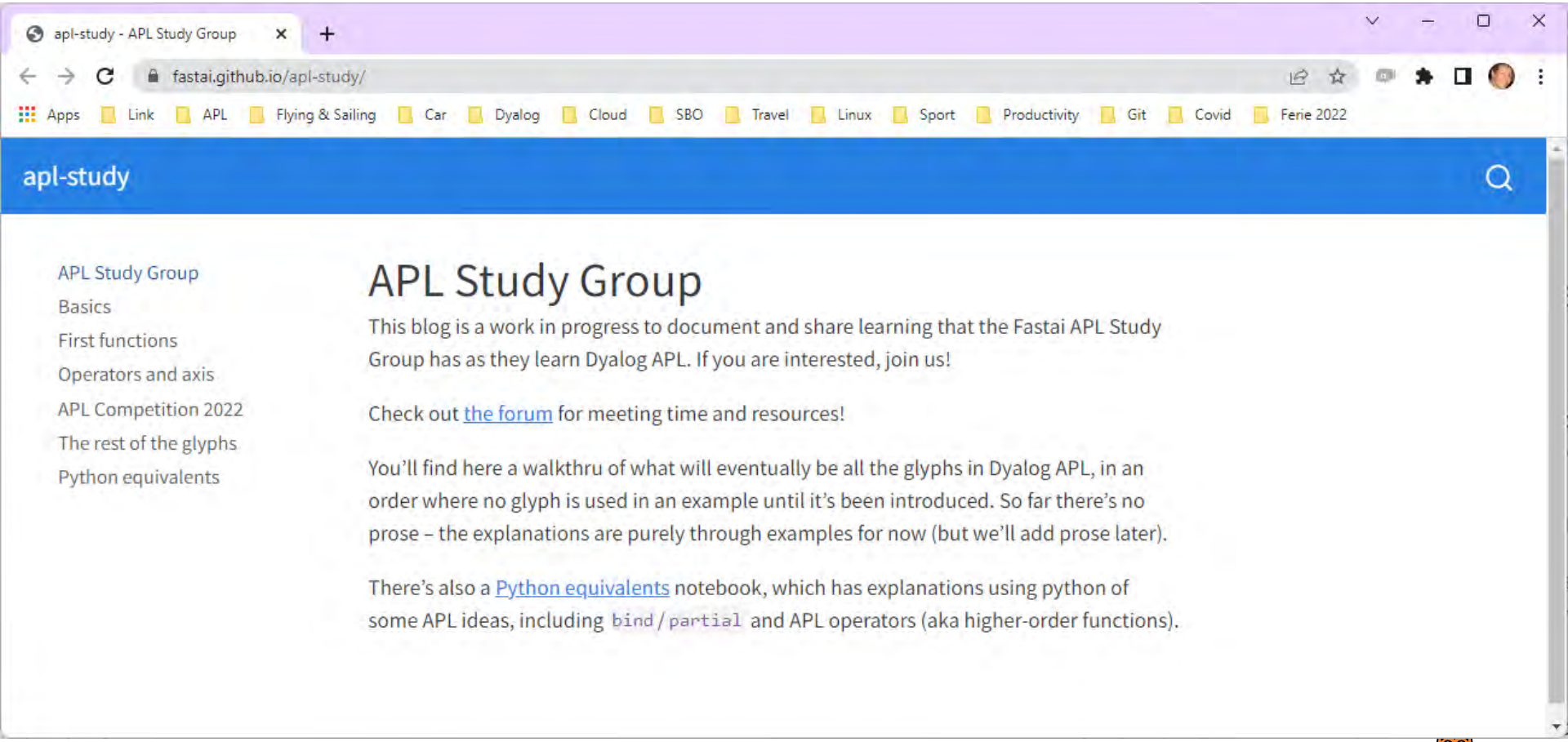
# 2. Training & Evangelism

- mastering.dyalog.com
  Rodrigo Girão Serrao
- course.dyalog.com
  Rich Park
- tutorial.dyalog.com
  Gary Bergquist + Andrew Sengul
- xpqz.github.io/learnapl
  Stefan Kruger (IBM)






apl-study - APL Study Group
fastai.github.io/apl-study/
Apps
Link
APL
Flying & Sailing
Car
Dyalog
Cloud
SBO
Travel
Linux
Sport
Productivity
Git
Covid
Ferie 2022
apl-study
APL Study Group
Basics
First functions
Operators and axis
APL Competition 2022
The rest of the glyphs
Python equivalents
APL Study Group
This blog is a work in progress to document and share learning that the Fastai APL Study Group has as they learn Dyalog APL. If you are interested, join us!
Check out the forum for meeting time and resources!
You'll find here a walkthru of what will eventually be all the glyphs in Dyalog APL, in an order where no glyph is used in an example until it's been introduced. So far there's no prose – the explanations are purely through examples for now (but we'll add prose later).
There's also a Python equivalents notebook, which has explanations using python of some APL ideas, including bind / partial and APL operators (aka higher-order functions).

Jeremy Howard (entrepreneur) - Wikipedia

en.wikipedia.org/wiki/Jeremy_Howard_(entrepreneur)

Apps | Link | APL | Flying & Sailing | Car | Dyalog | Cloud | SBO | Travel | Linux | Sport | Productivity | Git | Covid | Ferie 2022

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Community portal
Recent changes
Upload file

Tools
What links here
Related changes
Special pages
Permanent link
Page information
Cite this page
Wikidata item

Print/export
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Printable version

Languages
مصرى

# Jeremy Howard (entrepreneur)

From Wikipedia, the free encyclopedia

**This article has multiple issues.** Please help improve it or discuss these issues on the talk page. [hide]

*(Learn how and when to remove these template messages)*

- This article **contains content that is written like an advertisement**. *(April 2020)*
- The topic of this article **may not meet Wikipedia's notability guideline for biographies**. *(July 2020)*

**Jeremy Howard** (born 13 November 1973) is an Australian data scientist and entrepreneur.[3] He began his career in management consulting, at McKinsey & Company and AT Kearney. Howard went on to co-found FastMail in 1999 and Optimal Decisions Group. He later joined Kaggle, an online community for data scientists, as President and Chief Scientist.

Together with Rachel Thomas, he is the co-founder of fast.ai, a research institute dedicated to make Deep Learning more accessible.[*citation needed*] Previously, he was the CEO and Founder at Enlitic, an advanced machine learning company in San Francisco, California.

Howard teaches data science at company Singularity University. He is also a Young Global Leader[*citation needed*] with the World Economic Forum, and spoke at the World Economic Forum Annual Meeting 2014 on "Jobs For The Machines."[4] Howard advised Khosla Ventures as their Data Strategist, identifying the biggest opportunities for investing in data-driven startups and mentoring their portfolio companies to build data-driven businesses.

**Contents** [hide]



**Jeremy Howard**

Howard in Maui, 2014

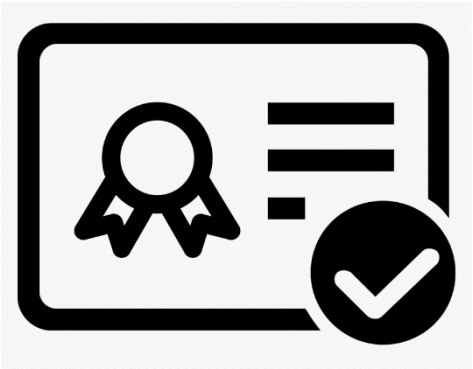
| | |
|---|---|
| **Born** | 13 November 1973 (age 48)<br>London, England |
| **Nationality** | Australian |
| **Alma mater** | University of Melbourne |
| **Occupation** | Entrepreneur |
| **Known for** | Deep Learning, Machine Learning |
| **Awards** | Winner of global Kaggle Data Science Competitions, 2011 and 2010[1][2] |
| **Website** | http://jhoward.fastmail.fm.user.fm/ |

# Training & Evangelism

- We trained a group of 24 developers in India last year (via Zoom)
- The materials prepared for this exercise are available free of charge at course.dyalog.com
  - This will be the case for all training materials that we are creating
- We are also considering running on-line courses – contact us if you need training!

# Basic Licence

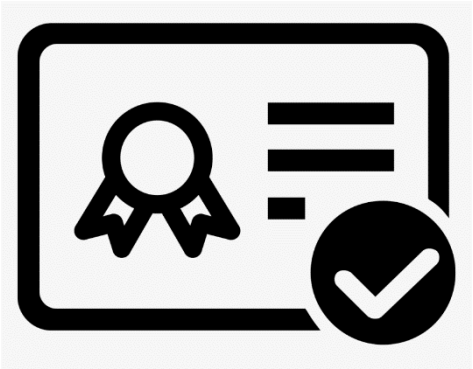
- Replaces *non-commercial licence*
- Allows distribution of Dyalog along with your work, under the default royalty licence
  - Fee is 2% of gross APL-based revenue
  - No fees due if revenue < GBP 5,000 in a calendar year
  - Multiple alternative commercial licence schemes are available
- For GBP 150 per year, you can subscribe to the Dyalog Support Service (DSS)



# Basic Licence

Perhaps the most important "feature" of v18.2 – intended for

- non-commercial use
- education
- personal projects & experiments
- sharing your experience
- proof of concepts / trials
- participating in programming competitions for cash prizes
- fun



# Keyboarding on all platforms

**Issues:**

- Dyalog IME does not work with Windows Universal Windows Platform applications
- APL keyboards do not work in RIDE (backtick still works) under Wayland (Linux)
- New users report that "ctrl" is problematic as the APL key

**Immediate Solutions:**

- Keyboards for Windows which use different "APL" keys (Alt, AltGr, etc)
- Backtick-style keyboards for all platforms

**Longer Term:**

- A new IME which offers a similar experience across supported platforms and works in and out of the IDEs (this will take a bit longer)

# 2. Training & Evangelism

**U16** Dyalog and Academia
(Jesús Galàn López and Gitte Christensen)

**U17** What – Another APL Book?
(Ray Polivka)

**D16** Growing APLers
(Rich Park)




# 3. Consulting

- We started building a consulting group in the USA in 2019
  - Paused due to Covid and other factors
- We expect to resume recruiting APL consultants in the USA next year
- Get in touch
  - … if you need consulting (also outside the USA)
  - … know someone interested in an APL career

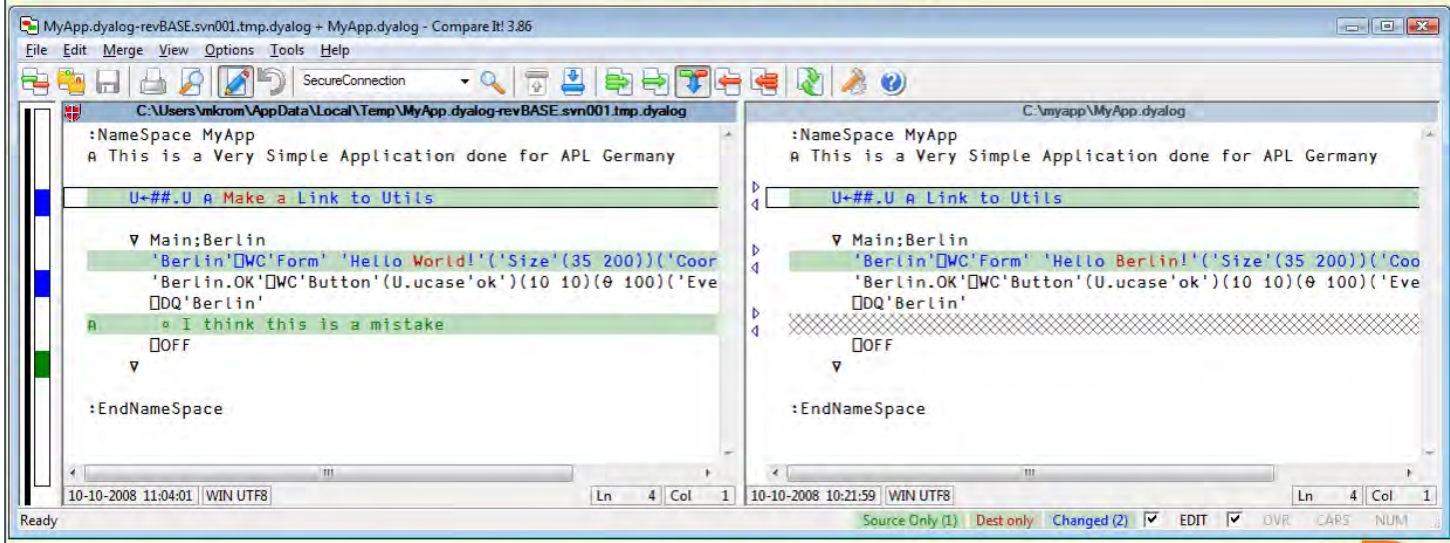
# 4. Source

- Here he goes again

DYALOG

## Source Code Mgt Demo

- All tools shown here downloaded from internet, none of them knew about APL in any way.



# Why is Text Source IMPORTANT?












# 4. Source in Text Files

Done:

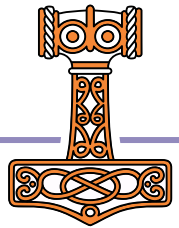
- Link 3.0 included with v18.2
  - Compatible with v18.0
  - Will replace SALT
- Launch APL from text source
  - No workspace required
  - Right-click on a function or namespace source file in Windows Explorer and run it
  - Also supported in containers
- HashBang/Shebang scripting

Project Managers:

- Acre
- Dado
- Cider

Package Manager:

- Tatin



Tatin

tatin.dev/v1/packages

Apps | Link | APL | Flying & Sailing | Car | Dyalog | Cloud | SBO | Travel | Linux | Sport | Productivity | Git | Covid | Ferie 2022

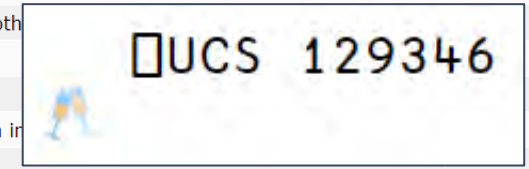
# Tatin Registry

**List of all packages (aggregated)**

| Package name | Description | Major versions | Link to project |
|---|---|---|---|
| aplteam-APLGit | Git interface from Dyalog APL via Git Bash | 1 | github.com |
| aplteam-APLProcess | Start an APL process from within Dyalog APL | 1 | github.com |
| aplteam-APLTreeUtils2 | General utilities required by most members of the APLTree library | 1 | github.com |
| aplteam-CodeCoverage | Monitors which parts of an application got actually executed | 1 | github.com |
| aplteam-Compare | Allows comparing and merging objects in the workspace with a file or a file with another file | 2 | github.com |
| aplteam-CompareSimple | Allows comparing objects in the workspace with a file or a file with another file | 2 | github.com |
| aplteam-DateAndTime | Utilities related to Date and Time, including doing math | 1 | github.com |
| aplteam-DotNetZip | Zipping and unzipping with.NET Core on all major platforms | 2 | github.com |
| aplteam-EventCodes | Constants with meaningful names for Dyalog error codes | 1 | github.com |
| aplteam-Execute | Start a process from within APL | 1 | github.com |
| aplteam-FilesAndDirs | Utilities for doing gymnastics with files and directories | 1 | github.com |

(... many more of Kai's packages skipped ...)

| | | | |
|---|---|---|---|
| aplteam-WindowsEventLog | Tools to read from and write to the Windows Event Log | 1 | github.com |
| aplteam-ZipArchive | Zipping and unzipping with .NET on Windows and zip/unzip on oth | 2 | github.com |
| davin-DateTime | Easy calculations with dates | 1 | github.com |
| davin-FilePlus | Extend component files to use named components | 1 | github.com |
| davin-SQLFns | Easily create text SQL commands for use with any SQL program in | 1 | github.com |
| davin-Tester | Simplified function-level testing of programs | 1 | github.com |
| dyalog-HttpCommand | Utility to execute HTTP requests | 1 | dyalog.github.io |
| dyalog-Jarvis | JSON and REST Web Service Framework | 1 | dyalog.github.io |



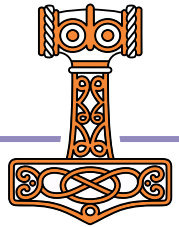
# 4. Source in Text Files

Still to do:

- Publish more [Dyalog] packages on the Tatin server
- Cider Project Manager
- Array Notation

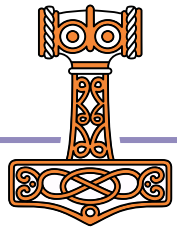
Current Use:

- Major customers have moved to text source
- New users tend to start with text source
- All new Dyalog tools are [open] text source on GitHub
  - Taking advantage of Continuous Integration for automated testing



# Demo – Starting APL from Text

- APL Script
- Open APL on a Folder

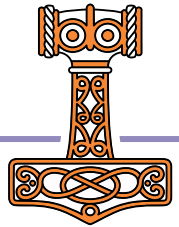


# Literal Array Notation

- Constants can form part of the "source" of an application
  - Enumerations
  - [Translated] strings
  - Conversion tables
- A notation for constants is an important piece of the "text source puzzle"
  - (In addition to being generally useful in code)

File Errors.apla

```
[ 2 'SYNTAX'
  3 'INDEX'
  4 'RANK'
  5 'LENGTH'
  6 'VALUE' ]
```

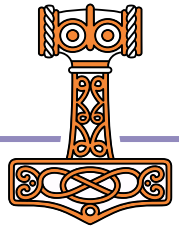


# 4. Source in Text Files

**Workshop SA3**: Link, Text-Based Source,
and Source Code Management
(Morten Kromberg and Josh David)

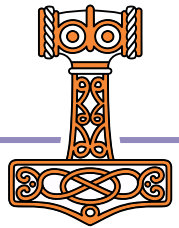
**D05** The P words... Project and Packages
(Morten Kromberg)

(also used in many other workshops and presentations)



# 5. Service Orientation

It must be easy to run APL as a service
and call it from other environments.



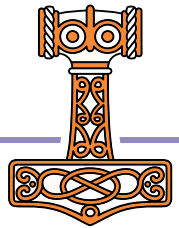
# Running APL as a Service

Imagine you have two pieces of business logic written in APL:

```
sum←+/
reverse←⌽
```

If you start Jarvis with a reference to the namespace containing the functions, Jarvis makes them available as a "Web Service":

```
Server←Jarvis.Run 8080 #
```



# Six different examples of calling "sum":

JavaScript

```
var xhr = new XMLHttpRequest();
xhr.open("POST", http://localhost:8080/sum);
xhr.setRequestHeader("content-type", "application/json");
xhr.send("[1,2,3,4]");
xhr.response;
```

PowerShell

```
$url = http://localhost:8080/sum
$hdrs = @{'content-type' = 'application/json'}
$body = '[1,3,5,7,9,11]'
Invoke-WebRequest -Method Post -URI $url -Headers $hdrs -Body $body
```

Python

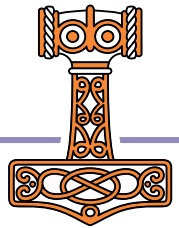
```
url = 'http://localhost:8080/sum'
hdrs = {"content-type":"application/json"}
array = [2,4,6,8]
resp = requests.post(url, data=json.dumps(array), headers=hdrs)
print(resp.json())
```

curl

```
curl -d "[1,2,3,4,5]" -H "content-type:application/json" http://localhost:8080/sum
```

APL

```
HttpCommand.GetJSON 'post' 'localhost:8080/sum' (⍳5)
```



# 5. Service Orientation

It must be easy to run APL as a service and call it from other environments.

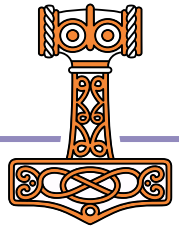
**Jarvis Web Service Framework**

- Replaces "JSONServer"
- Supports REST and "plain" HTTP/JSON services
- Widely available

  https://github.com/dyalog/jarvis
  https://hub.docker.com/r/dyalog/jarvis
  https://tatin.dev

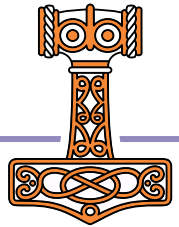
**Related Improvements**

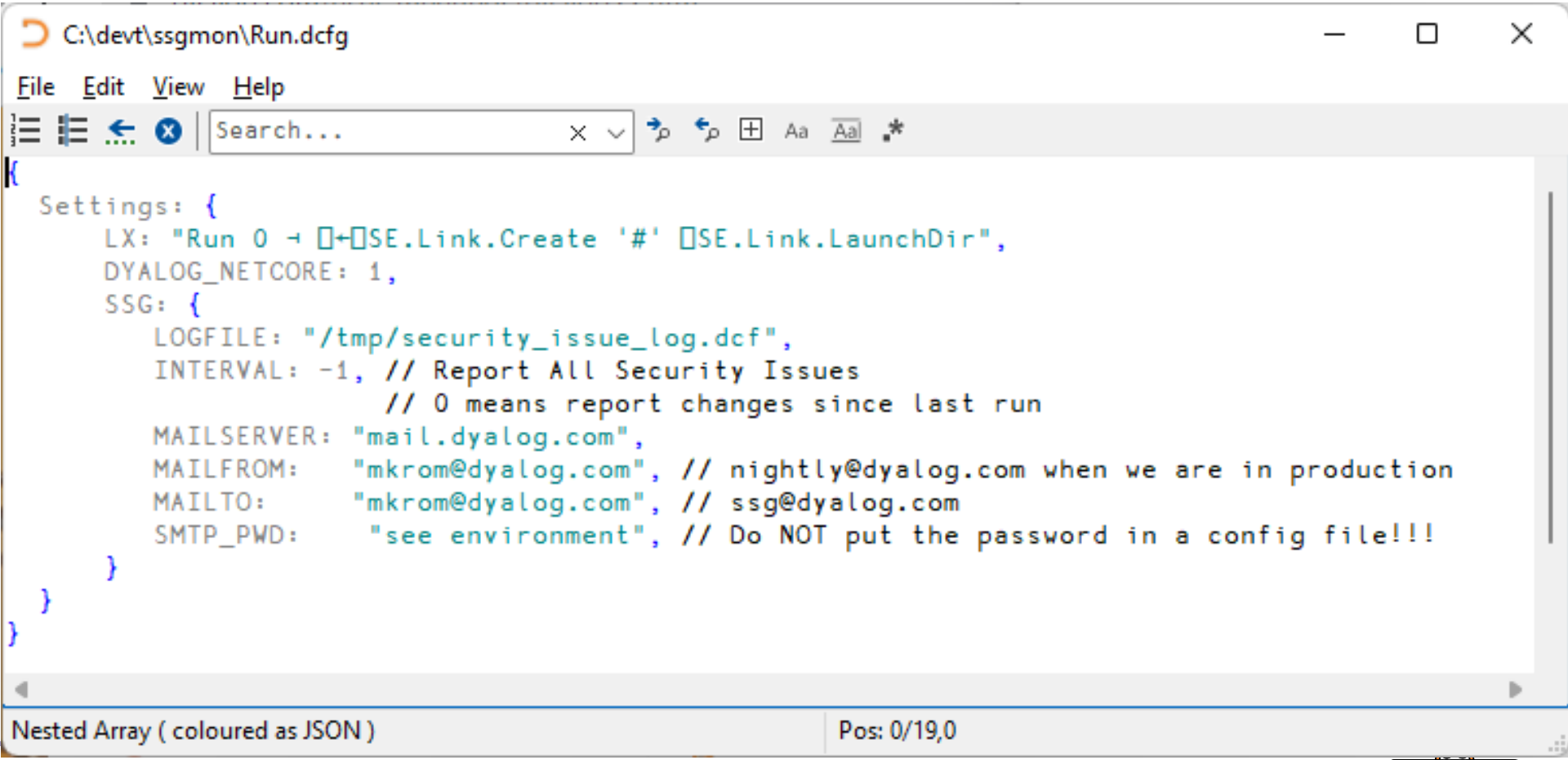
- Version 18.2 runs headless comfortably
  - Easier to use in containers
- RIDE 4.4 supports debugging threaded code
- ⎕JSON support for converting matrices to JSON tables



# 5. Service Orientation

- Continue work to make platforms more similar
  - Develop under Windows/macOS, deploy under Linux
- .NET Bridge provides cross-platform libraries & frameworks
- Unify configuration across platforms
  - All settings configurable via text files
  - Remove need for the Windows Registry
    - (Except perhaps to configure Windows IDE)




C:\devt\ssgmon\Run.dcfg
File Edit View Help
Search...
{
Settings: {
LX: "Run 0 ⍝ ⎕SE.Link.Create '#' ⎕SE.Link.LaunchDir",
DYALOG_NETCORE: 1,
SSG: {
LOGFILE: "/tmp/security_issue_log.dcf",
INTERVAL: -1, // Report All Security Issues
// 0 means report changes since last run
MAILSERVER: "mail.dyalog.com",
MAILFROM: "mkrom@dyalog.com", // nightly@dyalog.com when we are in production
MAILTO: "mkrom@dyalog.com", // ssg@dyalog.com
SMTP_PWD: "see environment", // Do NOT put the password in a config file!!!
}
}
}
Nested Array ( coloured as JSON )
Pos: 0/19,0

# 5. Service Orientation

- Materials developed for Dyalog'22 workshops will be extended over the next weeks and months
- We will publish a fully worked example of how to build a web service in Dyalog APL
  - Deployed in containers to the cloud
  - Scalable using several alternative mechanisms
  - User Sessions using 3rd Party Authentication
  - Encrypted Data
- More webinars, webcasts & samples to come

# 5. Service Orientation

Provide interface to monitor the state of APL processes

- CPU consumption
- Memory usage, Compaction counts, etc
- Are any threads suspended?
- )SI and Error information
- Available via API and / or protocols like SNMP

First version of monitor protocol planned for v19.0

# 5. Service Orientation

**Workshop SA2** Building Web Services with Jarvis (Brian Becker)

**Workshop SP2** (Brian Becker & Morten Kromberg)

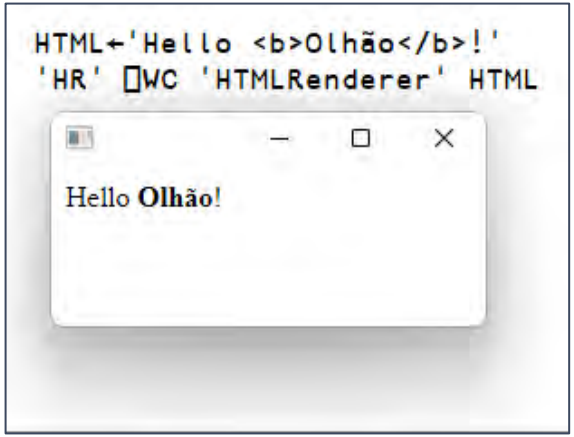
**U13** Automatic Application Builds with AWS (Norbert Jurkiewicz)

**D12** Simplifying Secure, Scalable Web Services (Brian Becker)

# 6. Cross Platform UI

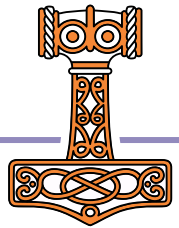
When APL Services behind other GUI won't do...

- Adoption of the HTMLRenderer is growing as the delivery mechanism for new UI
  - Appeared in 4 user presentations at Dyalog'22
- No clear choice of tool to generate HTML/JS
  - DUI/MiServer still has a small user base
  - Users are experimenting with writing own tools
  - ... and integrating HTML/JS generated by 3rd party tools or developers



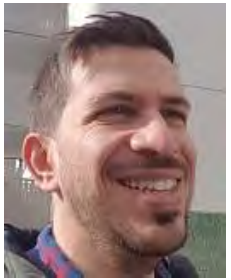
# HTMLRenderer improvements

- Most important: Find a way to easily upgrade the Chromium Embedded Framework
  - In the medium term, turn the HTMLRenderer into an Open Source project to allow community participation
- Enhancement in v19.0
  - Support Multiple windows that take turns being modal



# 6. Cross Platform UI

**U02** Lift-Off from APL2 Mainframe to Dyalog in the Cloud
(Gilgamesh Athoraya – Tiamatica AB)



**U04** A Modern APL Workbench
(Kimmo Linna - Finnair)

**U12** TAMPA – Taming Mathematical Programming in APL
(Stephen Mansour – Misericordia University)

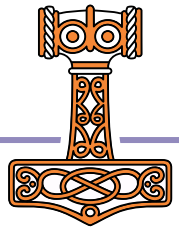
**U13** Integrating HTMLRenderer Into Existing Applications
(Norbert Jurkiewicz – The Carlisle Group)

# 7. [Microsoft].NET

As .NET celebrates 20 years of existence, Microsoft is pushing everyone to move from proprietary Microsoft.Net Framework to the new open source, cross-platform .NET.

| Name | Platforms | Version Numbers |
|---|---|---|
| Microsoft.NET Framework | Windows | 1 2 4 |
| .NET (previously ".NET Core") | Windows Linux macOS | 3 5 6 7 |

Dyalog v18.0 added a bridge to .NET 3, to complement the 20 year old bridge to the .NET framework.



# .NET Bridge

- Add support for .NET 5, 6 & 7
- Export APL code as .NET assemblies
  - v18 .NET bridge only allows USING .NET classes
- Generate APL-based applications under
  - Linux: Amd/Intel x64 and Pi/AWS on Arm64
  - macOS (x64 and M1/M2)
  - Windows (x64 – maybe Arm64 later)
- Work on support for Async features


.NET 6 is the current Long Term Support version of .NET

# 7. [Microsoft].NET

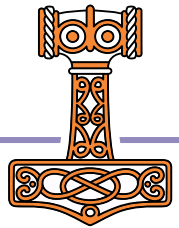
In a nutshell, the specification is that the new bridge it will work exactly the same way as the old one.

But there will be some enhancements.

# 8. New target Platforms

- 64-bit ARM
  - This low power RISC processor is gaining traction
  - We expect to support v19.0 on ARM64 (specifically M1 & M2 Macs)

- Web Assembly (WASM)
  - Co-dfns will target WASM as an execution platform (no release date)
  - We are likely to look at whether a cut-down interpreter engine could run in the browser (no timeframe)

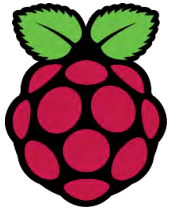


# Arm64

64-bit ARM chips are appearing in places that Dyalog should support:

- M1 & M2 Macs
- Raspberry Pi – 64 Bit
- Amazon Web Services "Graviton"



# Differences between Arm and x86

The primary difference between Arm and x86 processors is the way that they execute their instructions. x86 systems are based on complex instruction set computer (CISC) designs, while Arm is based on RISC designs. In short, x86 processors can execute multi-step operations on each instruction, while Arm processors use a limited, but highly optimized, set of instructions.

This execution difference is not the only reason that Arm is beginning to outperform x86 in important markets. Arguably, that change is due equally to Arm's attractive price-to-performance ratio.

For example, consider the AWS Graviton processor, Amazon's first AWS Arm offering. Arm can save AWS users as much as 40 percent in costs for performance equal to that of Amazon's previous x86 cloud processors.

Arm's flexible licensing process comes into play as a critical difference between Arm and x86. Intel's x86 processors are still a proprietary chip, meaning that Intel is the sole creator of the physical hardware and

Arm64 Performance Improvemer

devblogs.microsoft.com/dotnet/arm64-performance-improvements-in-dotnet-7/

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# Arm64 Performance Improvements in .NET 7

Kunal Pathak

September 12th, 2022 | 11 | 6

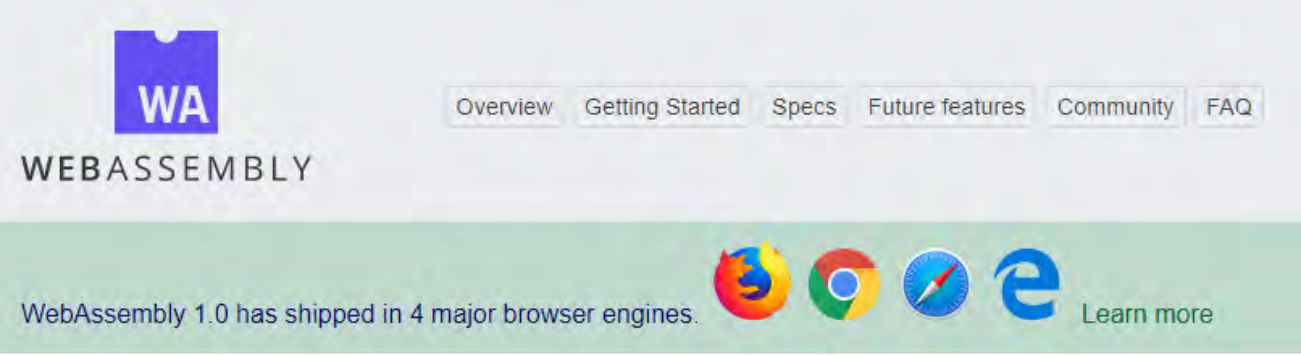
The .NET team has continued improving performance in .NET 7, both generally and for Arm64. You can check out the general improvements in the excellent and detailed Performance Improvements in .NET 7 blog by Stephen Toub. Following along the lines of ARM64 Performance in .NET 5, in this post I will describe the performance improvements we made for Arm64 in .NET 7 and the positive impact it had on various benchmarks. Stephen did touch upon some of the work in his blog post, but here, I will go through some more details and wherever possible include the improvements we have seen after optimizing a specific area.

When we started .NET 7, we wanted to focus on benchmarks that would impact wide range of customers. Along with the Microsoft hardware team, we did lot of research and thinking on what benchmarks should we pick that can improve the performance of both client and cloud scenarios. In this blog, I will start by describing the performance characteristics that we thought are important to have, the methodology we used, the criteria we evaluated to select the benchmarks used during .NET 7 work. After that, I will go through the incredible work that has gone into improving .NET's performance on Arm64 devices.

Feedback

# Web Assembly (WASM)

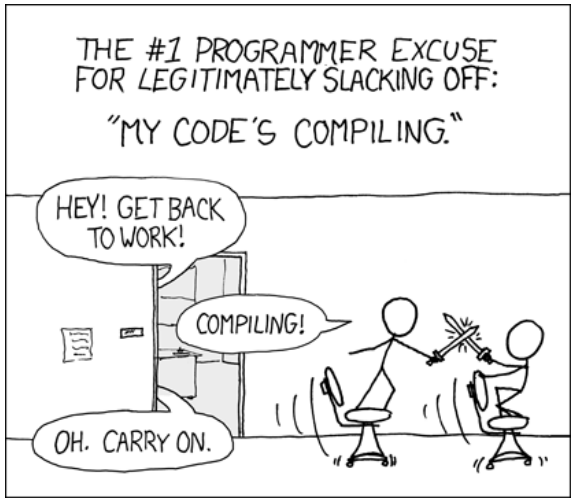
APL running in the browser...



# 8. New Target Platforms

**D11** Report on Co-dfns
(Aaron Hsu)

# 9. Compiling APL




Source: xkcd.com

Work on Co-dfns continues. 2023 targets:

- Almost complete language support, including Control Structures & TradFns
- Characters, Mixed Arrays, Complex Numbers
- New backend targets: WASM/Javascript, Scheme/Lisp, Java/C#, Python
- Tracing and debugging

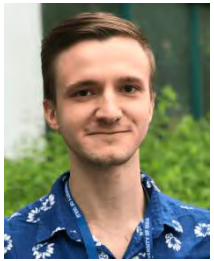
Emphasis as much on making APL accessible for new applications in new environments, as on compiling existing applications

# 9. Compiling APL

**D08** Implementing the Convolutional Neural Network U-net in APL
(Rodrigo Girão Serrão)

**U10** Scheduling Array Operations
(Juuso Haavisto – University of Oxford)

**D11** Report on Co-dfns
(Aaron Hsu)

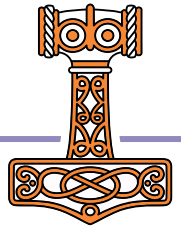


# 10. APL Language

- Literal Array Notation
- Multiple Numeric Towers, so we have a unified model which supports
  - 64-bit integers
  - Rational numbers
- Carefully considering which primitives are most important to add next. Not in a hurry.
  - Depth, Behind, Select, Under/Dual, etc...

Primitive Candidates

Select (X⍧Y)
Depth (f⍤k)
Behind (f⍥h)
Under (f⍢g)
Obverse (f⍣g)



# 10. APL Language

**D15** Filling the Core Language Gaps
(Adám Brudzewsky)

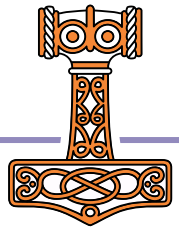
**D03, D04, D10 2022** Conference Edition Parts 1,2,3
(John Daintree)

# 2022 Conference Edition

Experimental features for you to play with

- I/O redirection & new Log File format
- Token-By-Token debugging
- Ideas for asynchronous programming in APL

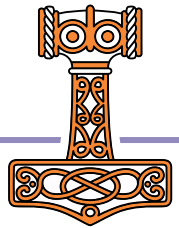
(only the first is likely to be in v19.0 in 2023)



# Download Conference Edition

https://www.dyalog.com/uploads/conference/dyalog22/presentations/

setup_120.22.46169.0_64_unicode_2022.10.28.zip



# Ten Lane Highway

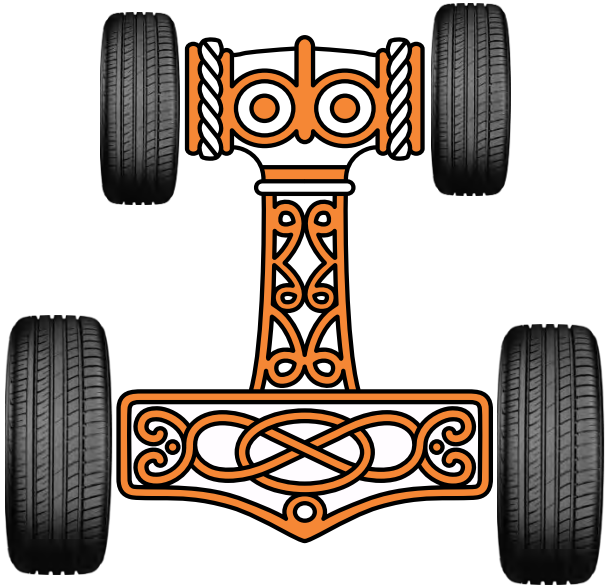
1. Building the Team
2. Training & Evangelism
3. Consulting
4. Source in Text Files
5. Service Orientation
6. Cross-Platform UI
7. [Microsoft].NET
8. New Target Platforms
9. Compiling APL
10. APL Language

APL Germany e.V.

DYALOG

Stuttgart, November 2022

# The Road Ahead



*Morten Kromberg*