Tcl in Jupyter

Achievements and to-dos

Stefan Sobernig

On Jupyter (1)

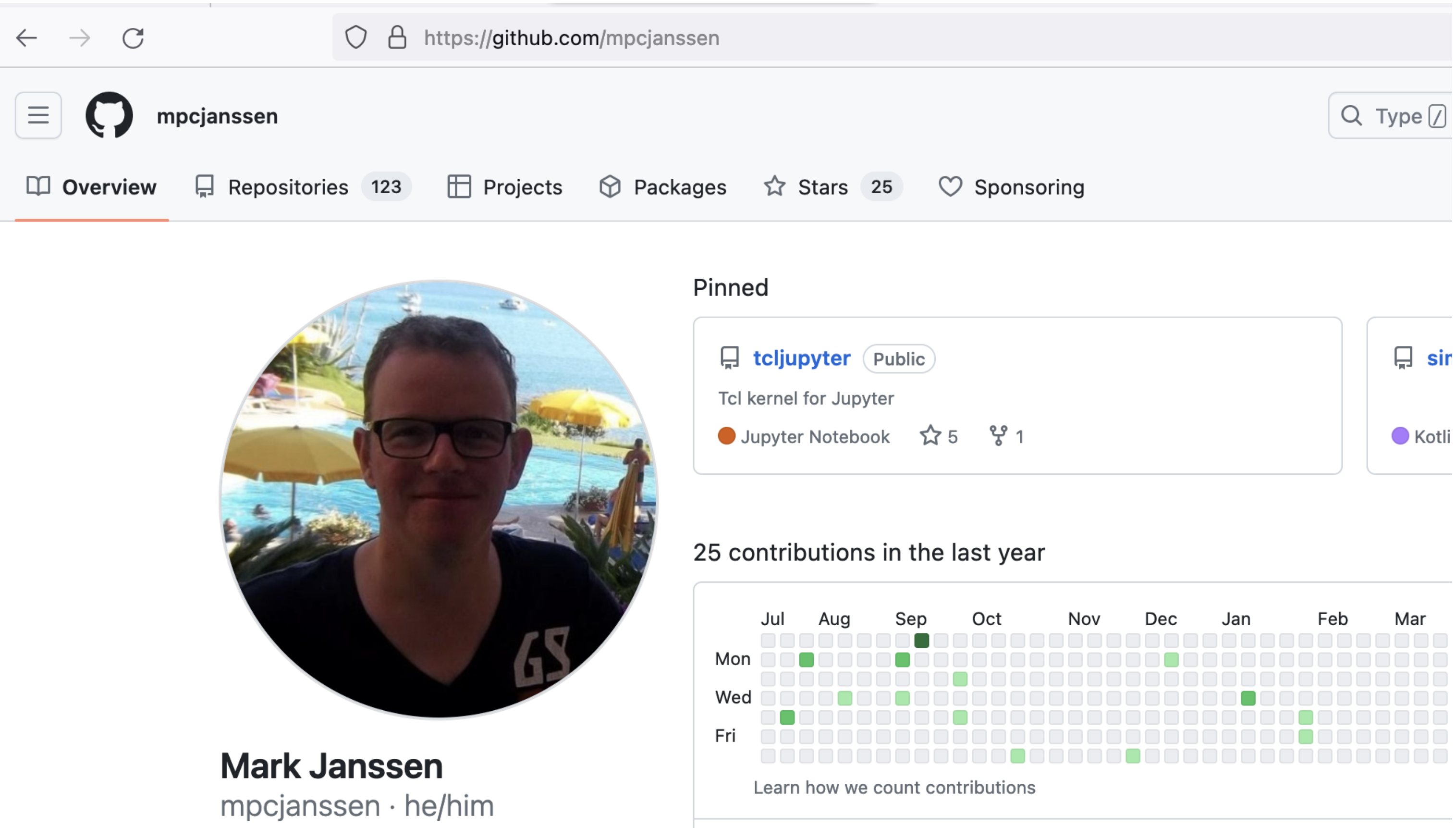
- Jupyter is a widely used interactive literate-programming environment (Data Science, and beyond).
- A Jupyter ***notebook*** is both an interactive, literate-programming document and, when integrated with a "kernel", an application that executes the document.
- The notebook format uses JSON to store all of its contents in “.ipynb” files.
- A notebook is composed of cells, which can be of three types: code, Markdown, and raw. A code cell contains executable code used to produce results.
- By default, Jupyter displays text, images (PNG, JPG, and SVG), ***HTML with JavaScript***, and Markdown; extensions may add to these display types.

On Jupyter (2)

- A Jupyter ***kernel*** executes code cells in a REPL manner.
- During the execution of a cell, the kernel communicates with Jupyter to display intermediate and final results.
- Notebooks are just one example of possible ***frontends*** to a Jupyter kernel; others include console applications, any HTTP or WebSocket clients, etc.
- Multiple frontends may be connected to the same kernel (e.g. a console and a notebook)!

All credits go to Mark Janssen!

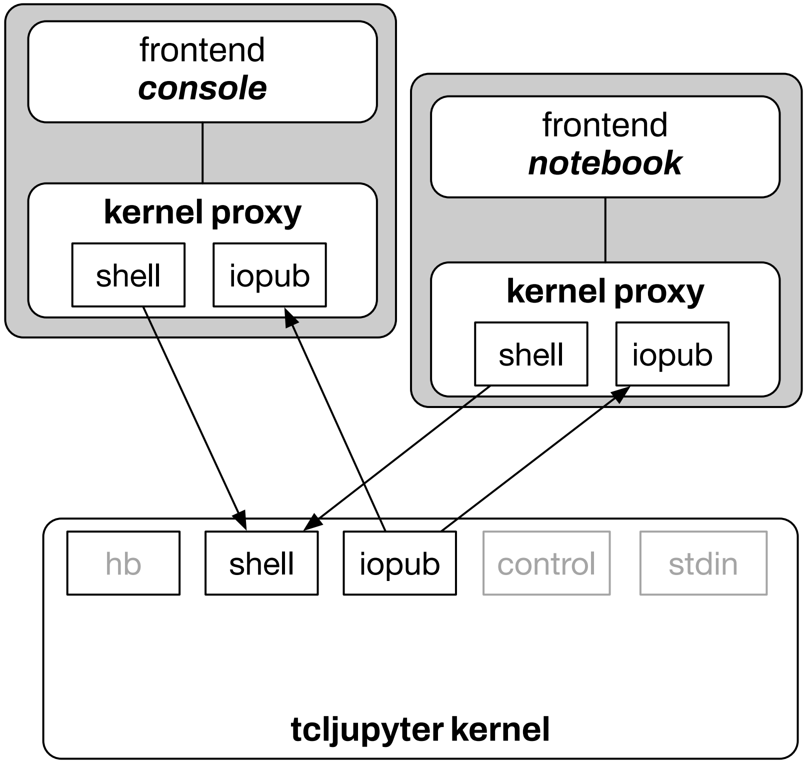
Visit https://github.com/mpcjanssen/tcljupyter



Tcl kernel for Jupyter

25 contributions in the last year

Mark Janssen
mpcjanssen · he/him



frontend
console
kernel proxy
shell
iopub
frontend
notebook
kernel proxy
shell
iopub
hb
shell
iopub
control
stdin
tcljupyter kernel

Connectors and message types

Kernel and frontends communicate via five different connectors (ZeroMQ sockets) which realise the Jupyter kernel messaging protocol:

- ***shell*** implements the main REPL behaviour via *action* requests/replies between one or more frontends and a given kernel (*message types*: execute, introspection, completion, history, kernel info)
- ***iopub***: side effects are broadcasted from the kernel to one or more frontends (*message types*: streams for stderr and stdout, displays carry data for rendering/visualisation in the frontend)
- ***control*** allows for controlling the kernel without interfering with shell actions (*message types*: shutdown, restart, debugging)
- ***stdin*** kernel can request user-provided input data from the frontend
- ***h***(eart)***b***(eat) allows for frontends and kernels to signal their liveliness to each other;

Overview of component interactions

… using a PlantUML sequence diagram

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... using a PlantUML sequence diagram

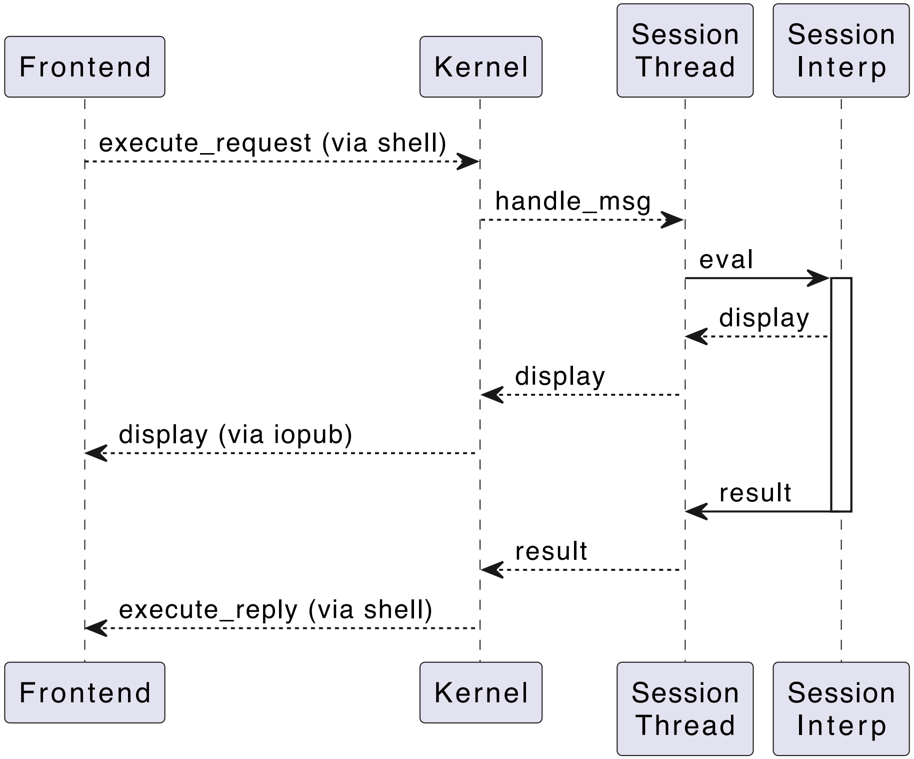
In [140]:

```
set seqDiagram {
  participant "Frontend" as FR
  participant "Kernel" as K
  participant "Session\nThread" as ST
  participant "Session\nInterp" as SI

  FR --> K : execute_request (via shell)
  K --> ST: handle_msg
  ST -> SI: eval
  activate SI
  SI --> ST: display
  ST --> K: display
  K --> FR: display (via iopub)
  SI -> ST: result
  deactivate SI
  ST --> K: result
  FR <-- K : execute_reply (via shell)
};
```

In [141]:

```
plantuml $seqDiagram
```



Noteworthy Tcl features used

- Runs a child interp (potentially, a safe or restricted interp)
- hosted by a Tcl "userland" thread via thread::create.
- "Dealer" thread and "session" thread communicate via thread::send -async.
- Standard I/O from code cells (stdout, stderr) is indirected using channel transforms.

Tcl packages used

- rl_json for marshalling/ unmarshalling
- tcllib: uuid and sha256 (for message signing)
- Thread to maintain the session thread
- tclzmq as a Tcl binding to ZeroMQ

Display Data

- Send back data computed by the code cells within the kernel to become displayed in the frontends (text, html, svg, etc.).
- An own message type at the messaging level (`display_data` that travels via the `iopub` connector).
- `tcljupyter` offers dedicated commands available to Tcl scripts in code cells to send display data to the frontend:
    - `jupyter::html`
    - `jupyter::updatehtml`
    - `jupyter::update`

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In [142]:

```
set displayId [jupyter::html {<b>Say, Tcl 9 is out!</b>}];
```

~~Say, Tcl 9 is out!~~

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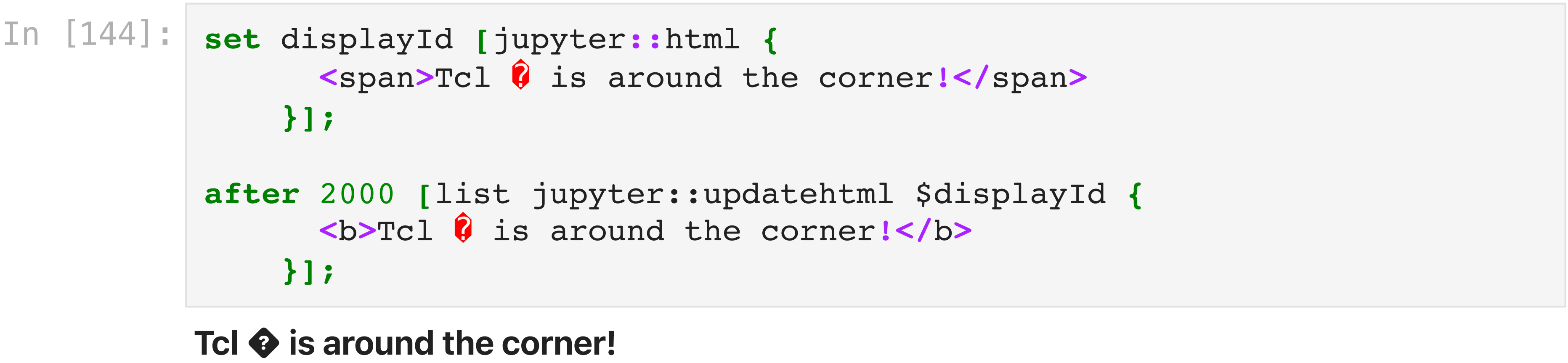
In [142]:

```
set displayId [jupyter::html {<b>Say, Tcl 9 is out!</b>}];
```

~~Say, Tcl 9 is out!~~

In [143]:

```
jupyter::updatehtml $displayId {<s>Say, Tcl 9 is out!</s>};
```



In [144]:

```
set displayId [jupyter::html {
      <span>Tcl � is around the corner!</span>
    }];

after 2000 [list jupyter::updatehtml $displayId {
      <b>Tcl � is around the corner!</b>
    }];
```

Tcl � is around the corner!

Integrating `ticklecharts` via Display Data

See https://github.com/nico-robert/ticklecharts

```
In [145]: package req ticklecharts
```

```
Out[145]: 3.1.5
```

Example 1: Conference stats

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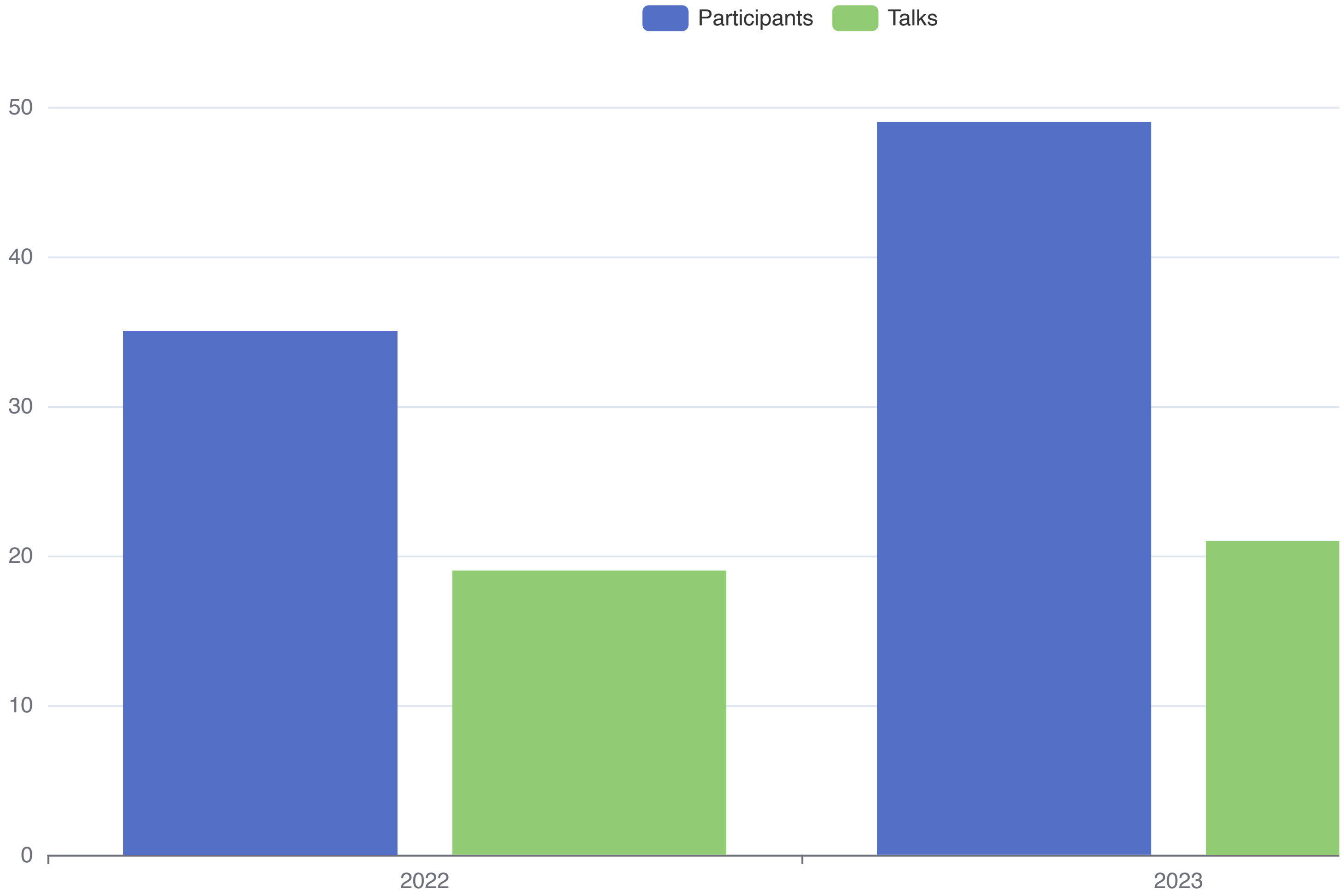
In [147]:

```
set chart [ticklecharts::chart new]

$chart SetOptions -tooltip {
                    show "True" trigger "axis"
                    axisPointer {type "shadow"}
                  } \
                  -legend {} \
                  -grid {
                    left "3%" right "4%"
                    bottom "3%" containLabel "True"}

$chart Xaxis -data {{2022 2023}}
$chart Yaxis

$chart Add "barSeries" -name "Participants" \
                       -data {{35 49}} \
                       -emphasis {focus "series"}

$chart Add "barSeries" -name "Talks" \
                       -data {{19 21}} \
                       -emphasis {focus "series"}
```

```
In [148]: $chart RenderJupyter -renderer svg
```



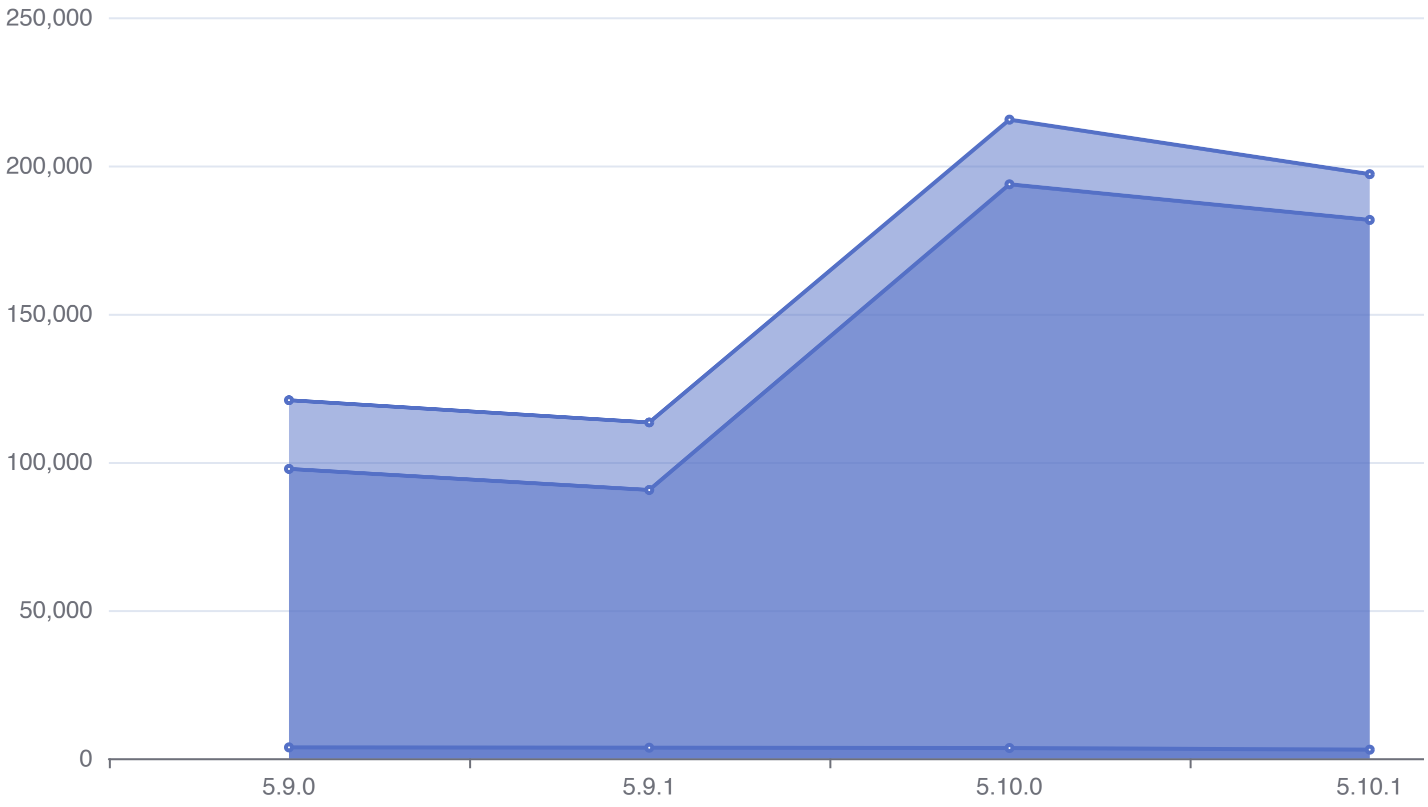
Example 2: OpenACS diff stats

Example 2: OpenACS diff stats

In [149]:

```
set chart2 [ticklecharts::chart new]

$chart2 Xaxis -data [list {"5.9.0" "5.9.1" "5.10.0" "5.10.1"}]
$chart2 Yaxis

$chart2 Add "lineSeries" \
    -data {{3658 3548 3445 2886}} \
    -areaStyle {}

$chart2 Add "lineSeries" \
    -data {{120800 113292 215464 197060}} \
    -areaStyle {}

$chart2 Add "lineSeries" -data {{97617 90507 193642 181613}} \
    -areaStyle {}
```

```
In [150]: $chart2 RenderJupyter -renderer svg
```



Alternative environments & kernels

- Christian Werner's Taygete Scrap Book (TSB): Tcl-based interactive, literate programming environment based on a `webview` frontend;
- Alternative Jupyter kernel: Is built using a Python "wrapper kernel" which reuses Tcl interp hosted by Python's Tkinter
- RStudio Rmarkdown notebooks: No Tcl integration so far (would require a `knitr` language engine, for instance)

Roadmap:

- Messaging infrastructure: Re-use or re-build?
    - Update `tclzmq`?
    - Complete `tcljupyters` pure-socket implementation (mind the ZeroMQ socket semantics)?
    - Use a thin `wrapper kernel` in Python to host a `tcljupyter` backend?
- Complete support for all message types (i.e., kernel functions)
- Deployment:
    - Distribution via a single executable (kit) for the main platforms plus self-installer?
    - How to deal with "wrapper kernel" in Python?
    - Batteries (tcllib, ticklecharts, tDOM, ...)
- Tests (`jupyter_kernel_test`) + documentation (along the way);

Summing up

Tcl in Jupyter ...

- contributes to the overall community goal to "making it easier for people to get and try Tcl" (Steve Landers);
- makes Tcl and its eco-system accessible to a non-Tcl audience;
- helps Tclers join the mainstream of interactive, literate programming environments;
- immediately useful to Tclers for the sake of *Tcling*:
    - to demonstrate your Tcl programs;
    - to create interactive presentations (RISE);
    - to create interactive documentation (e.g., Arjen's Jupyter port of the Tcl tutorial)
    - as an interactive development environment
    - 🤔 YOUR IDEAS? 🤷‍♂️

Kudos 👏 to Tcl community members

- 👉👉👉 Mark Janssen for tcljupyter 👈👈👈
- Nico Robert for ticklecharts
- Jos Decoster for tclzmq

References

- Pimentel et al. (2021): Understanding and improving the quality and reproducibility of Jupyter notebooks. Empir. Softw. Eng. 26(4): 65 (2021)