Stateful Client-Server Communication in the Era of Serverless Functions

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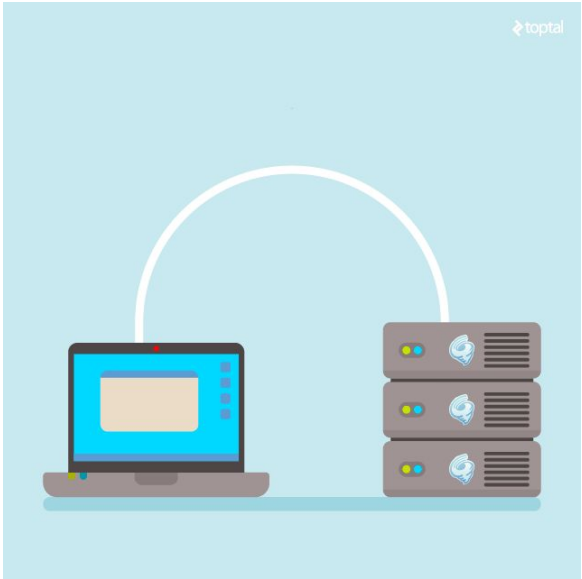
An old question, and yet again

How bad is stateful communication, now with “serverless functions”?



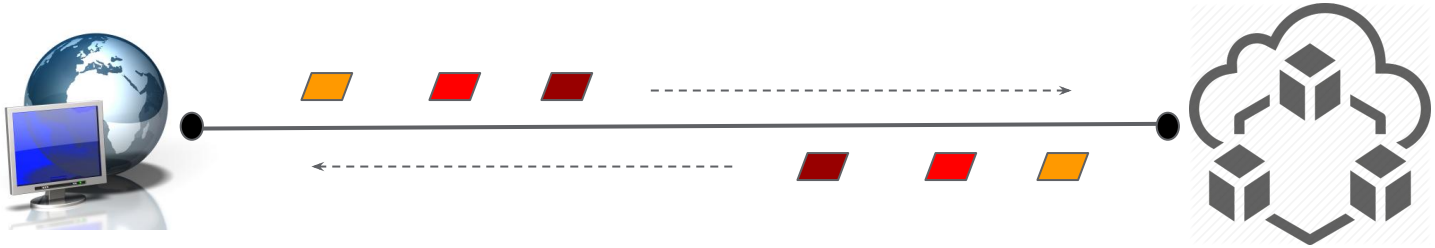
Stateful client-server communication

In a nutshell, “TCP socket” + message framing

- bidi gRPC, websockets ...

Compared to RPC (request-response)

- Full-duplex, FIFO and in-order delivery
- Non-causal semantics: server-push, one-way messages

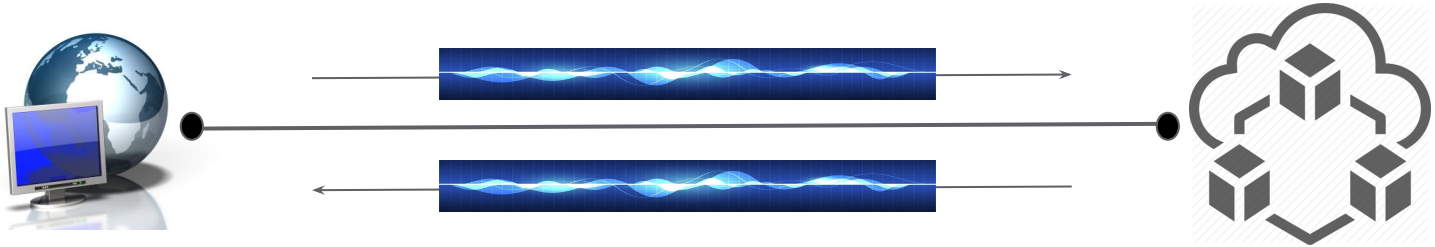


Where it works well

As an optimization to strict RPCs

- Causal relation between client and server-sent data
- Incremental & interleaved data delivery and processing
- Short-lived

“media transcoding”, i.e. full-duplex & streamed upload/download

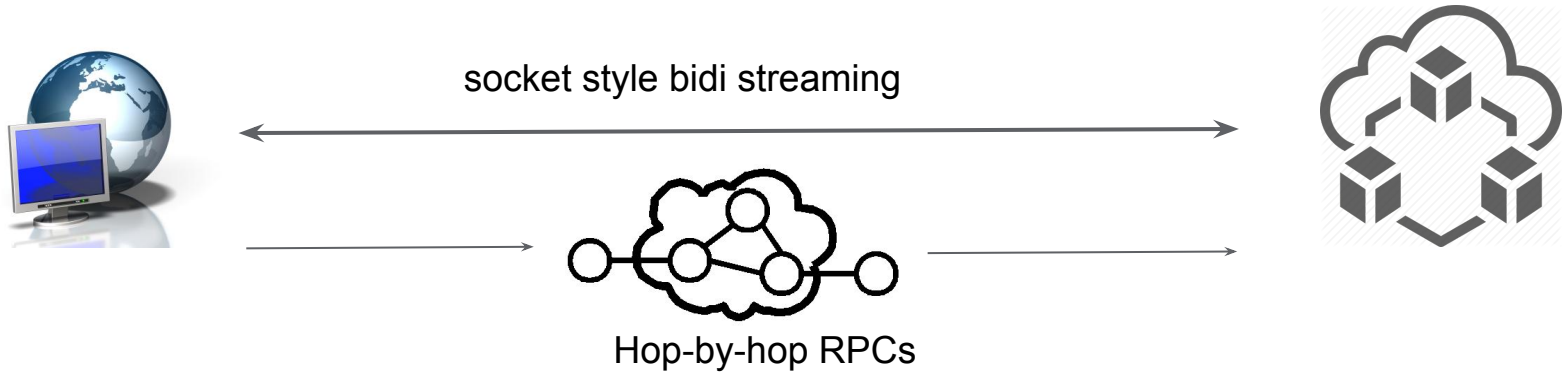


Where it becomes problematic

Spontaneous server-push or long-lived sessions

- Database watch (firestore)
- Chat, collaborative editing

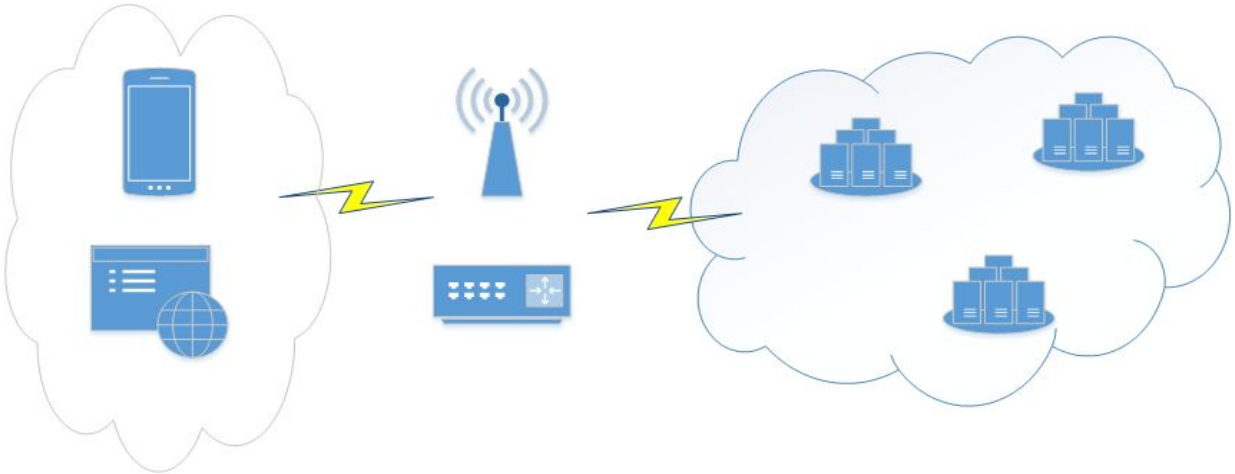
Stateless RPCs => stateful bidi streaming



Challenges

When the transport (TCP) is unreliable, i.e. Internet, cloud

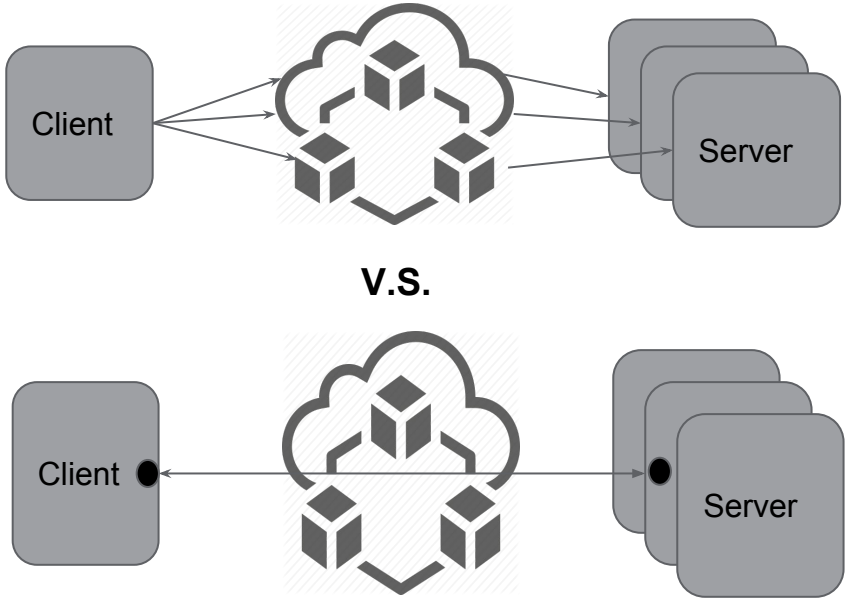
- No end-to-end ack
- Failure detection is hard or impossible



Challenges

For long-lived sessions

- Client-side: proxies, mobility
- Server-side: load-balancing, DoS prevention, security

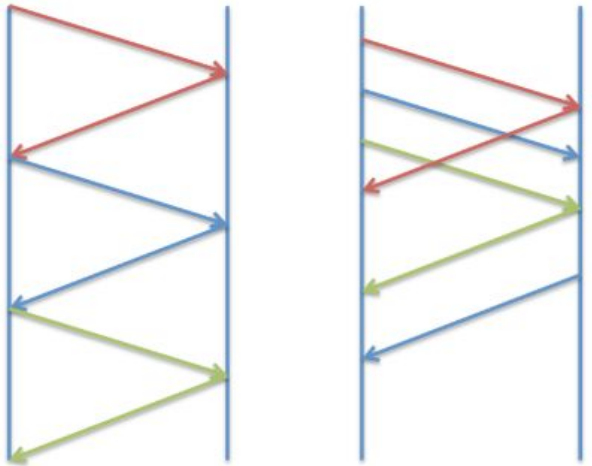


Performance benefits

- Latency: saving 1-RTT, compared to sequential polling
- Efficiency: cross-layer “batching”, esp. to skip redundant auth

Relative to the speed of light

- L1: ~2x
- L2-3: ~3x
- L4-7: ~10x



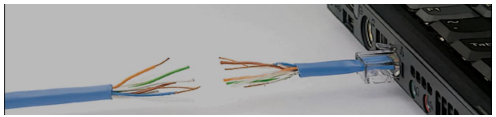
Higher-level abstraction

A single session that assumes FIFO, in-order and causal delivery

- v.s. independent & concurrent RPCs (which may fail too)

1. session = open(url)
2. session.send(msg)
3. session.on(“message”, callback)
4. session .close()

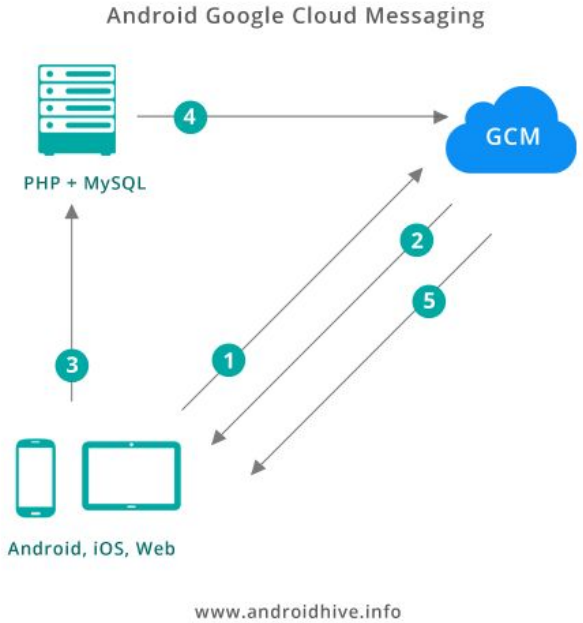
Util



State of the art

AppEngine, serverless

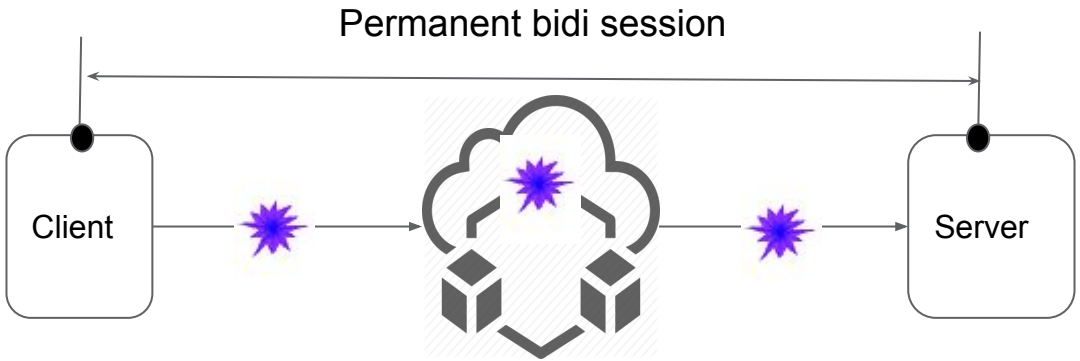
- Short sessions only, up to 60s
- Out-of-band pushes, via external messaging services



State of the art

Bidi-web (github.com/bidiweb)

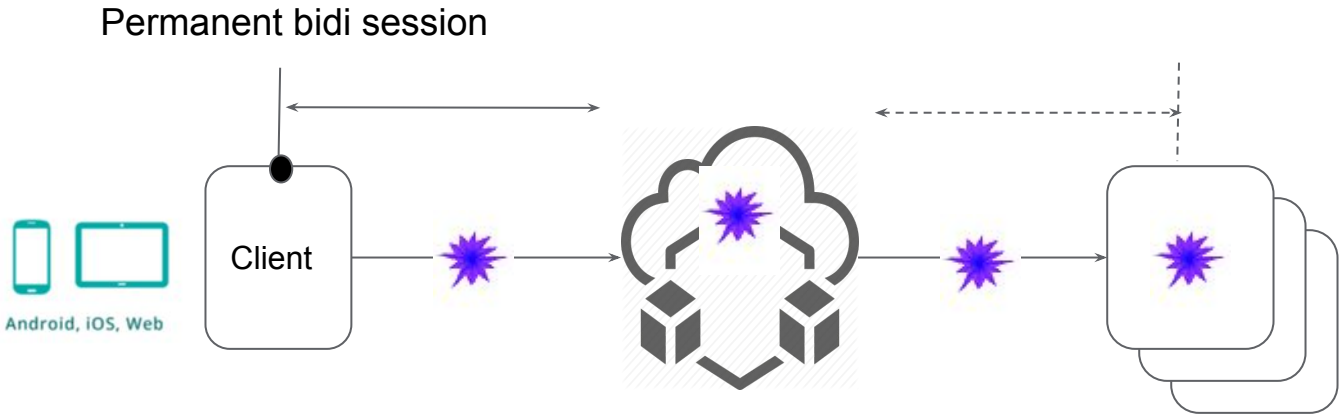
- A logical session over short & concurrent RPCs (HTTP)
- Server end-points are still stateful and long-lived



Can we have both?

Bidi-web model on serverless

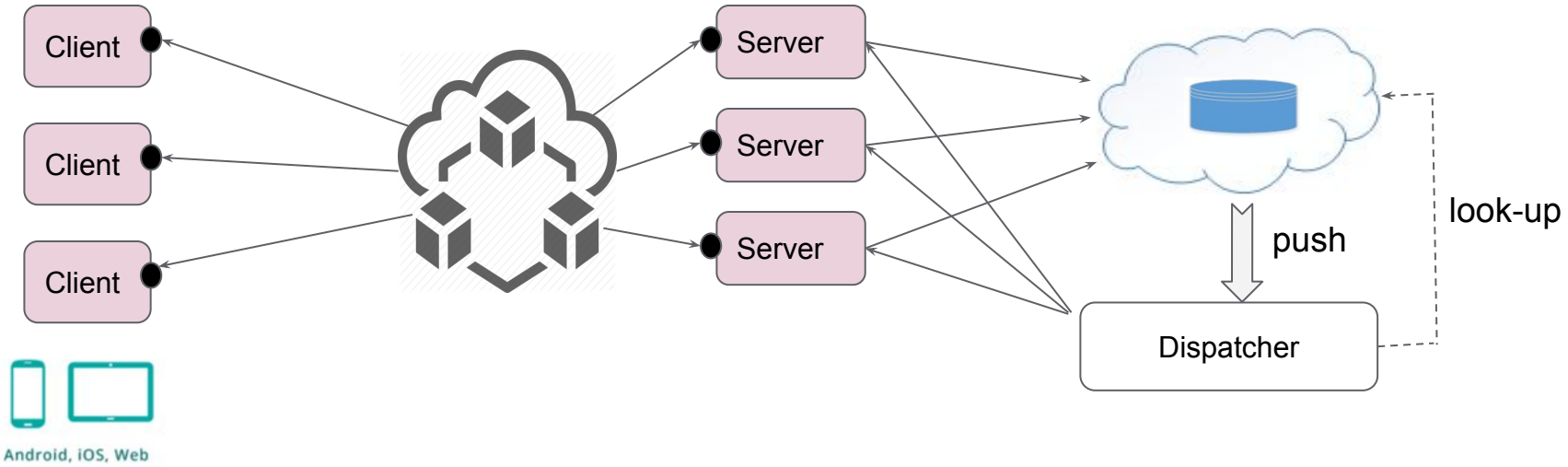
- Keep the client endpoint stateful
- Deploy the server endpoint as stateless functions



Case study: real-time chat

Stateful-server model

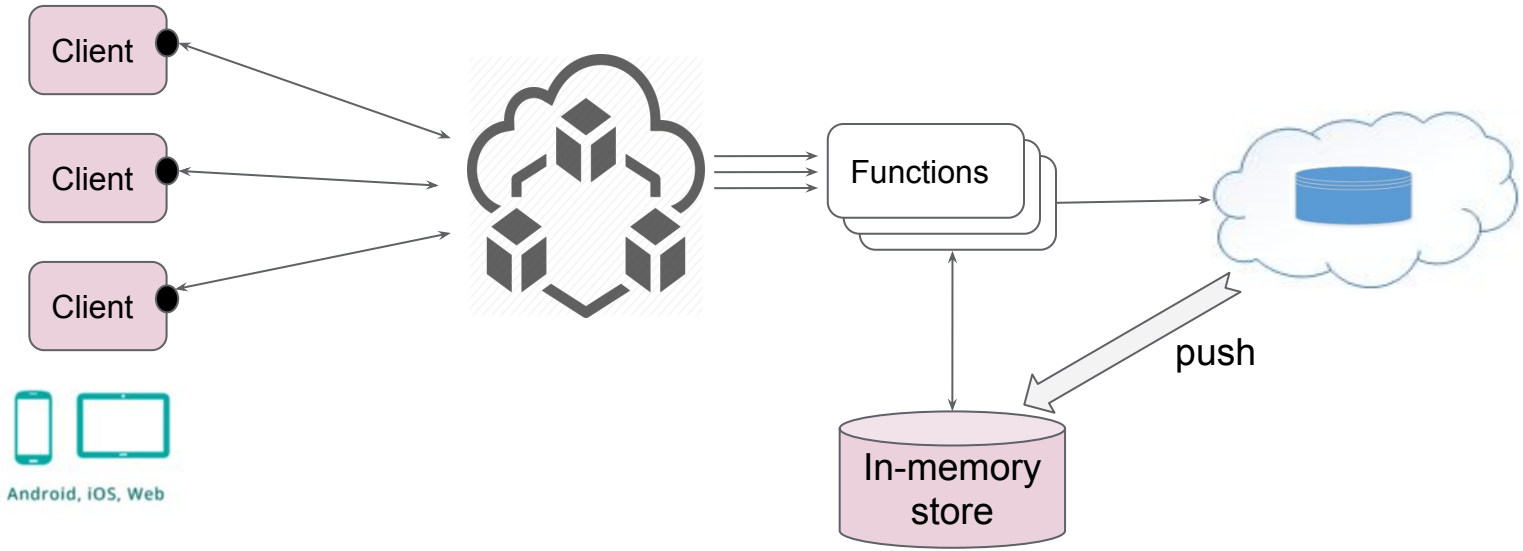
- A stateful end-point on the server-side for each client session
- Shared state for the “chat room”
- Stateless dispatcher to push messages to individual clients



Real-time chat on serverless

Externalized communication state

- In-memory store, e.g. Redis in a single cluster
- Stateless framework libraries as server functions



Accepts a new session

```
class ServerSession {
    void accept(...);
}
```

- *sid* represents an opaque client session id

Delivers a new client message

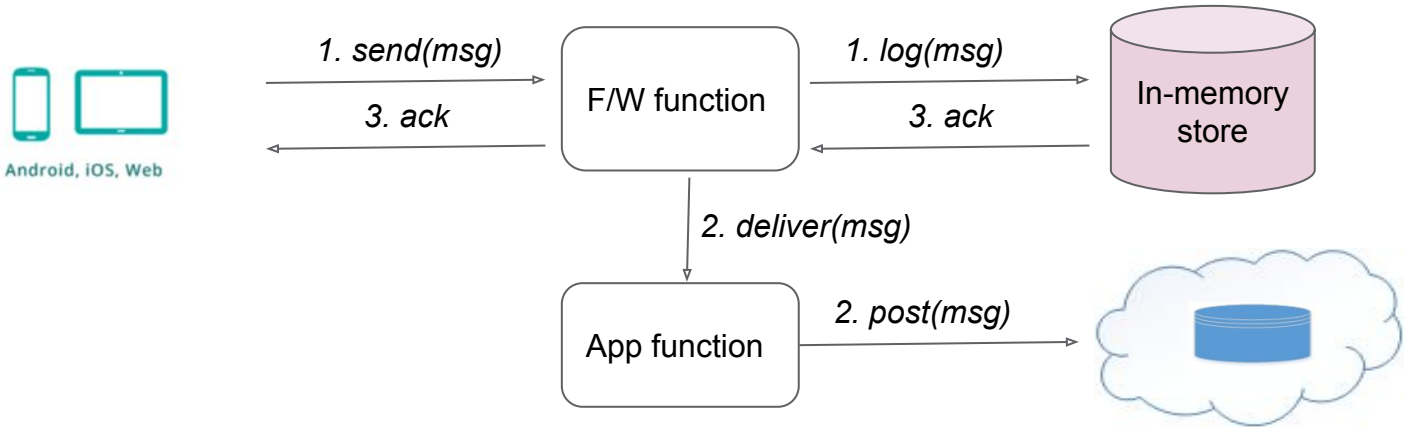
```
class ServerSession {
    void onMessage(msg);
}
```

- *send()* may include retried client messages
- *ack* may include retried server messages

Delivers a new client message

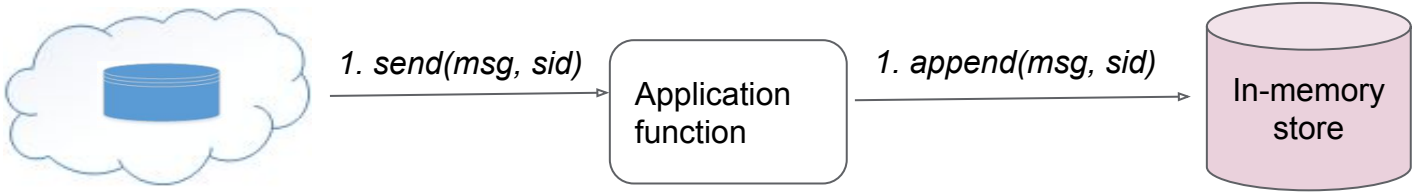
```
class ServerSession {
    void onMessage(msg);
}
```

- concurrent sends are expected
- messages are totally ordered



Delivers a new server message

```
class ServerSession {
    void send(msg):
}
```

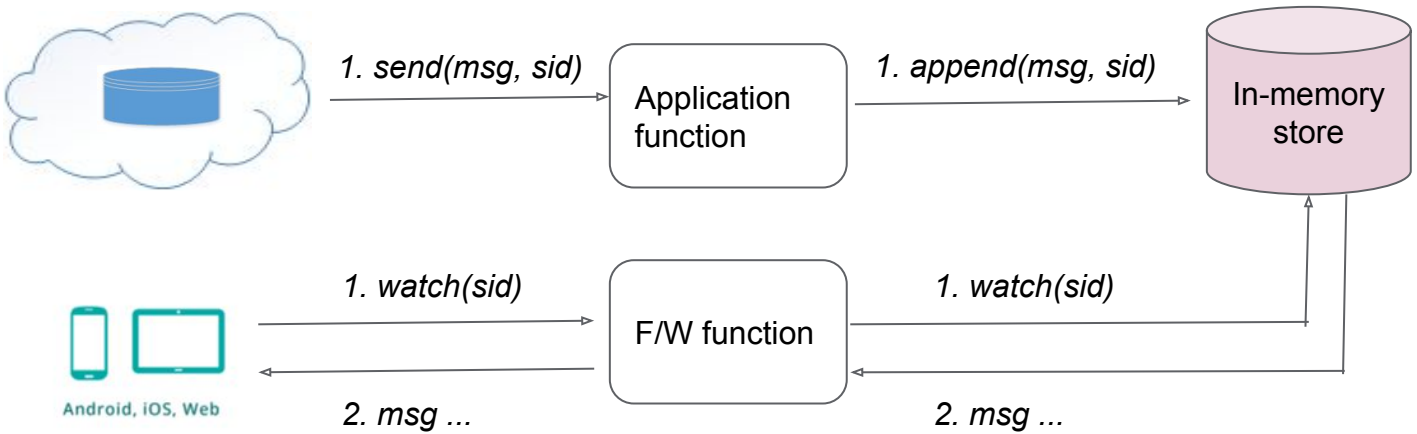


- storage layer to order messages per *sid*

Delivers a new server message

```
class ServerSession {
    void send(msg):
}
```

- *watch()* does be a short “Hanging GET”, e.g. < 60s



Framework roles

Ensure communication semantics

- Concurrency control of parallel client requests
- Message ordering, recovery, ack, flow-control ...

```
class ServerSession {
    void open(...);
    void onMessage(msg);
    void send(msg);
}
```

```
function open(sid, ...);
```

```
function onMessage(sid, ...);
```

```
function send(sid, ...);
```

Why not push services?

Compared to application-owned bidi endpoints

- Extra cost and latency
- Different ordering semantics

Future use cases

- Long-lived VR chats
- Extremely low-overhead storage, e.g. RAMCloud

Conclusion

- An intriguing architecture choice with both well-understood and new challenges
- Frameworks are expected to play a significant role

Questions, comments: web@google.com