DAP: Allowing more than one Helper (or not)

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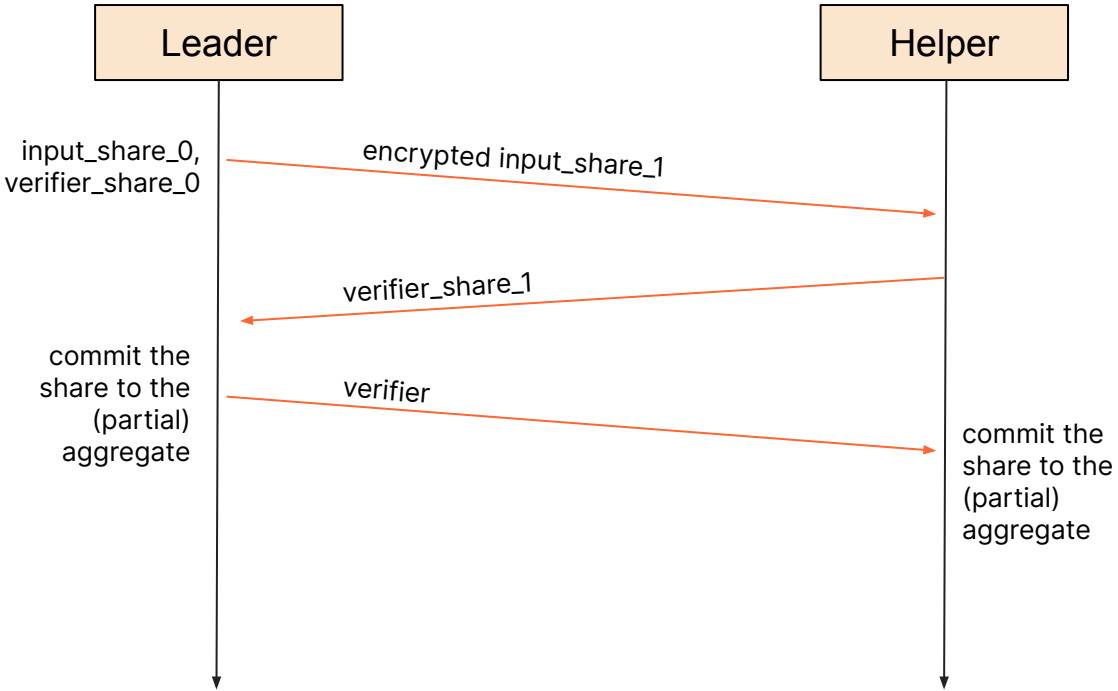
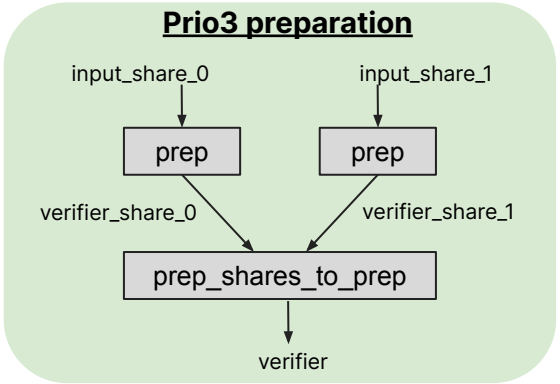
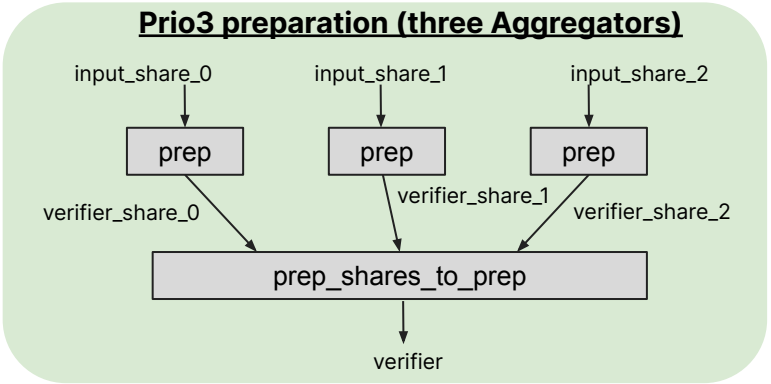
IETF 116 – PPM

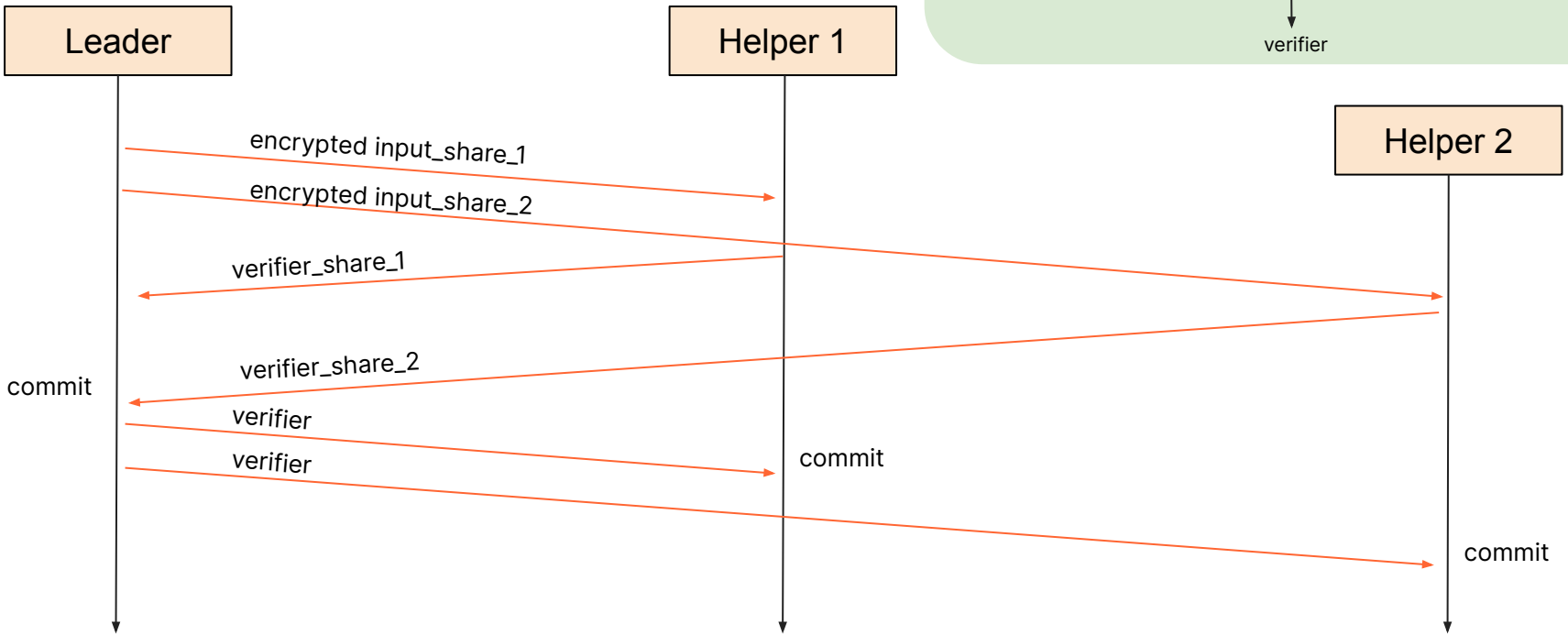
DAP-04 aggregation flow: Leader commits first



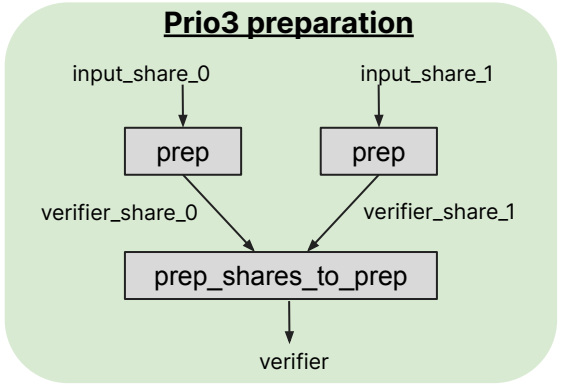


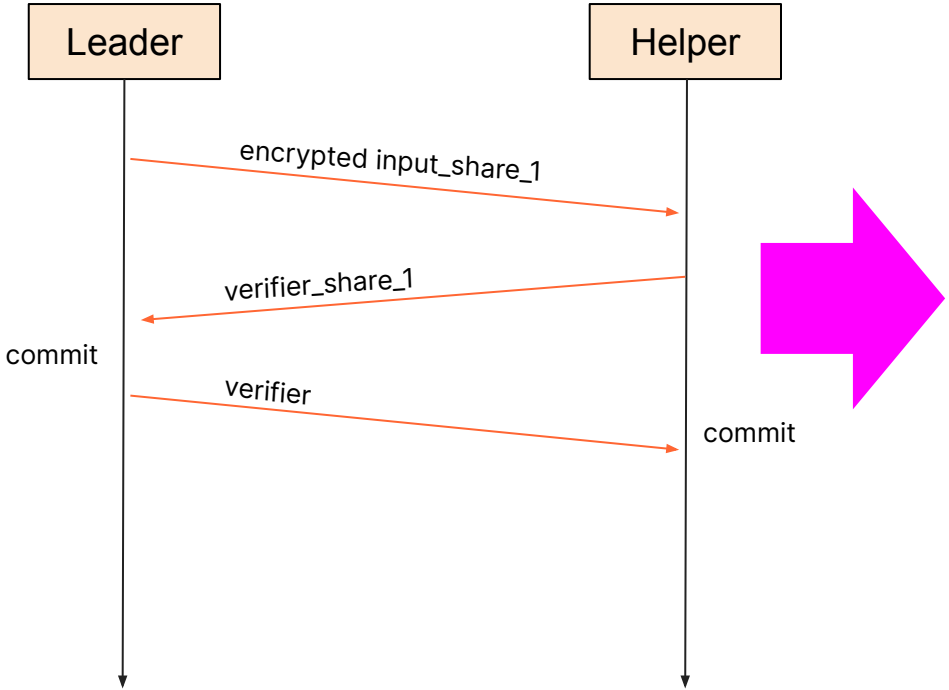
DAP-04 envisions multiple Helpers

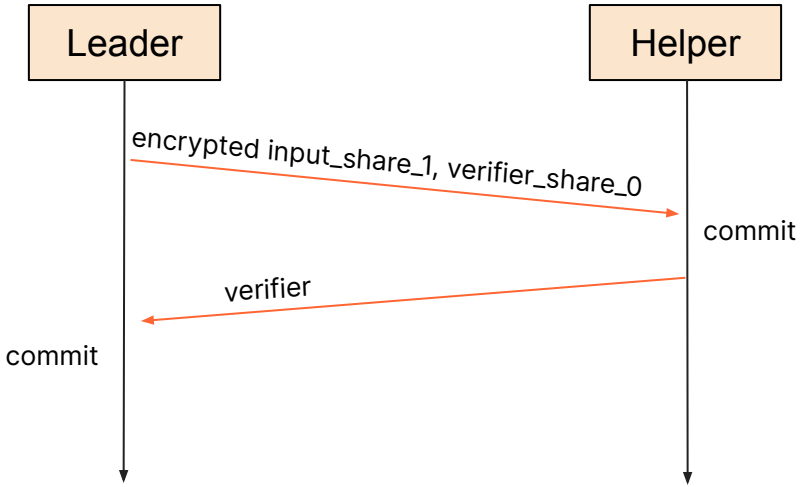




Alternative flow: Helper commits first

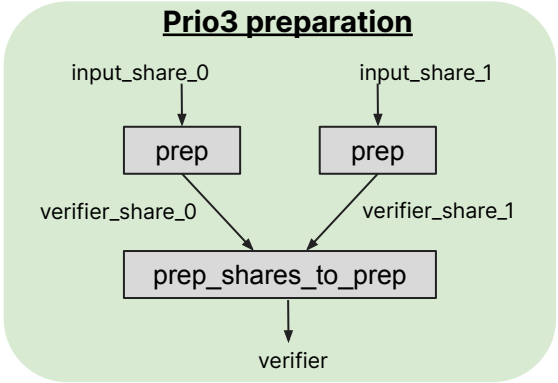


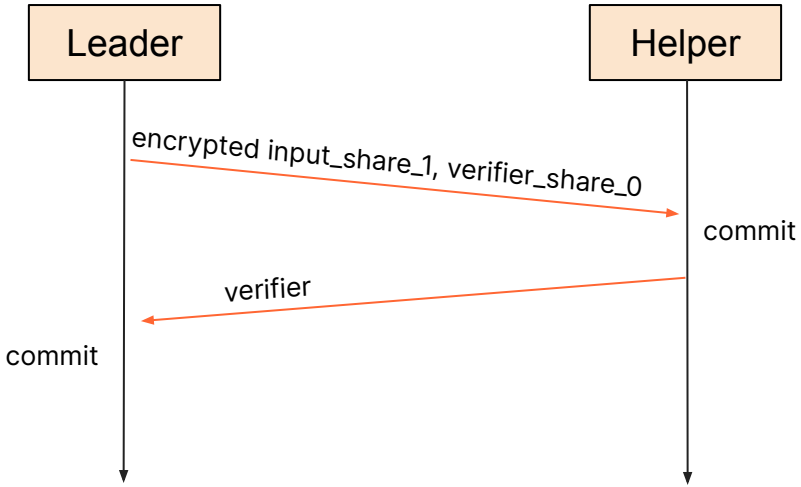




Alternative flow: Helper commits first

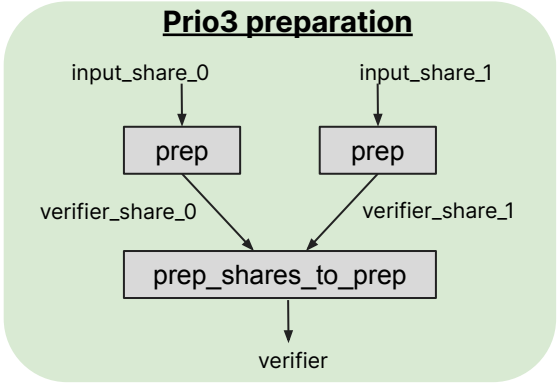
- Main upside: Fewer HTTP requests → reduced latency, impact of network issues
  - 1-round VDAFs (e.g., Prio3) take one request instead of two
  - 2-round VDAFs (e.g., Poplar1) take two requests instead of three
- Main downside: Loss of generality: No support for multiple Helpers
  - WG decision: **Shall we continue to support multiple Helpers in DAP or specialize the protocol for 1-Helper?**

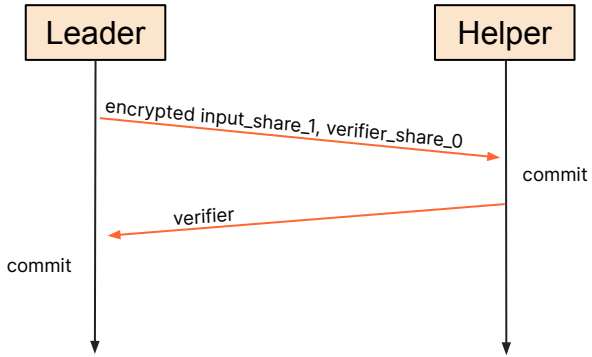




Consideration #1: Generality

- Use case (a): More Aggregators → Weaker trust model (It should be harder to collude if more organizations are involved)
    - Not all VDAFs support multiple Helpers (e.g., Poplar1)
- Use case (b): Robustness in the presence of a misbehaving Aggregator*
    - Idea [ia.cr/2019/188, ia.cr/2023/080]: Run a 2-Aggregator VDAF with each pair of 3 Aggregators; use majority vote to decide validity
        - If Leader acts as broadcast channel (as in DAP today), then we'd still have to trust it to not misbehave
- Use case (c): VDAF that requires three (or more) Aggregators to meet its security goals
    - No known examples of this (yet)
- Use case (d): MPC schemes other than VDAFs that require 3 or more Aggregators (e.g., the sorting scheme of [IPA])

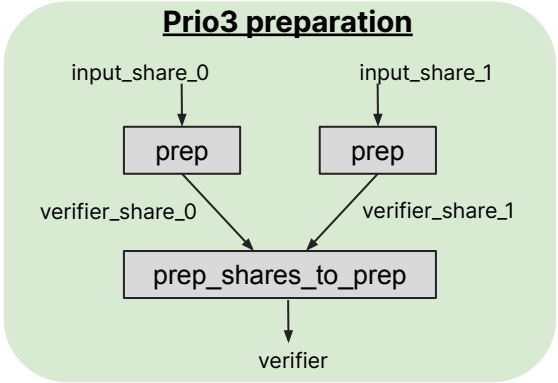


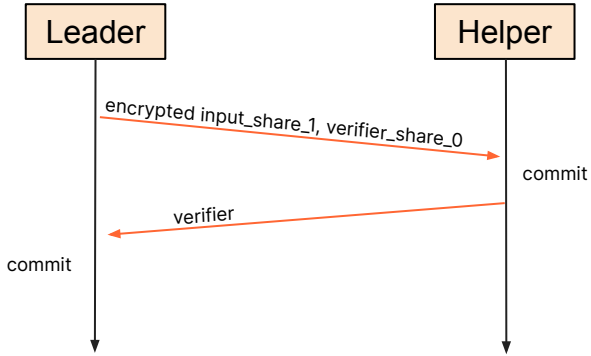


*Reminder: We currently have **privacy** in the presence of a malicious Aggregator, but not robustness.

Consideration #2: Complexity

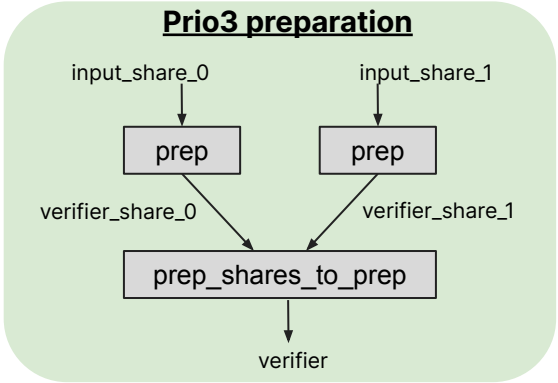
- Current draft is complex, due in part to generality of supporting multi-round, multi-Aggregator VDAFs.
- Complexity impedes adoption:
  - Undefined behavior in current draft
  - Harder to implement correctly
  - Harder to reason about security

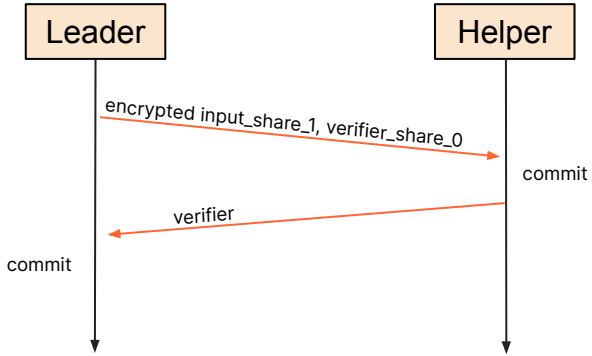




Consideration #3: State of current deployments

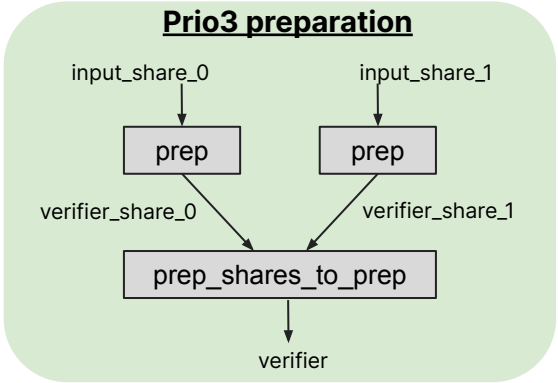
- Latency improvement requires reworking the aggregation flow: Perhaps too late in the game for such a large change?
  - Open-source implementations:
    - Janus (all roles)
    - Daphne (Aggregator only)
    - Firefox (Client only)
  - Known deployments: 3-month trial in Firefox Nightly (with ISRG and Cloudflare Research)
- (Another angle) More deployment experience with current architecture would help inform whether the latency improvement is needed in practice.

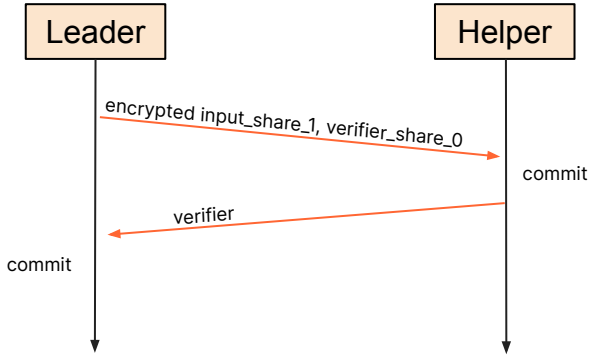




Consideration #4: Scope of DAP spec

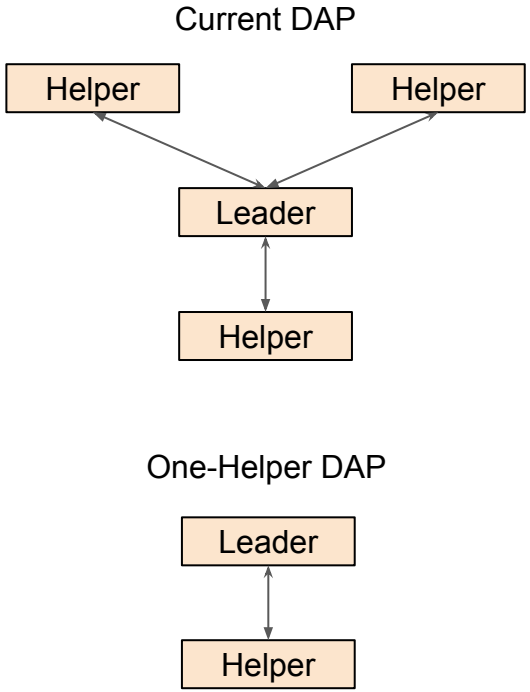
- PPM has a much broader mandate than specifying DAP
  - Other classes of MPC, STAR, and beyond: Different drafts for each, or one monolithic draft?
- Ship a spec now that we can deploy; leave more general behavior to future drafts
  - There are likely parts of the current DAP draft that we would want to re-use in future drafts, e.g., the API, security considerations, etc.





Proposal for 1-Helper DAP

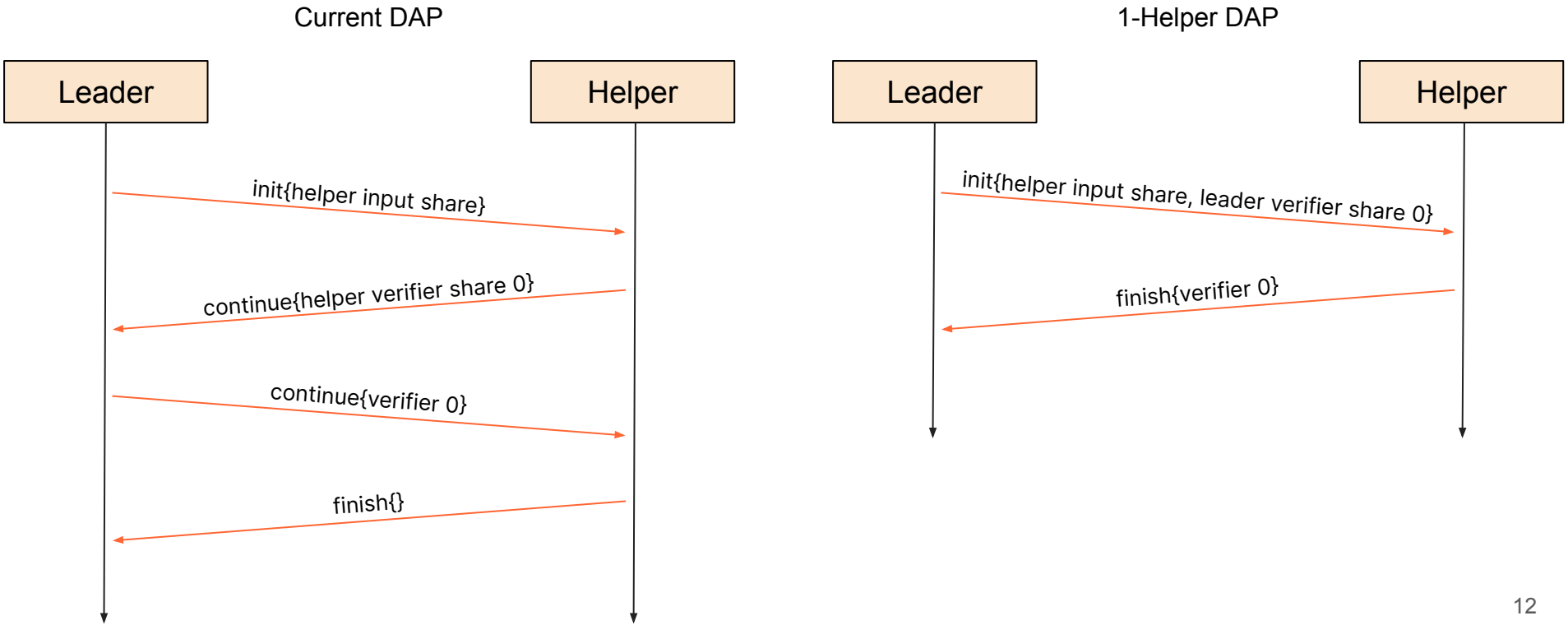
- Modify aggregation protocol to take advantage of one Helper [PR#393]
  - In current DAP, only the Leader can merge verifier shares into a verifier because only the Leader has all of the shares.
  - In One-Helper DAP, either aggregator can merge verifier shares into a verifier.
  - Effectively, the Leader no longer needs to act as a broadcast channel; protocol modification takes advantage of this. Aggregators “take turns” merging shares.
  - Total count & order of VDAF operations is not changed.
  - Total count of transmitted verifiers / verifier shares is not changed. (direction of communication changes in some cases)
  - Upshot: total count of network round-trips to complete aggregation is reduced by **about half**.



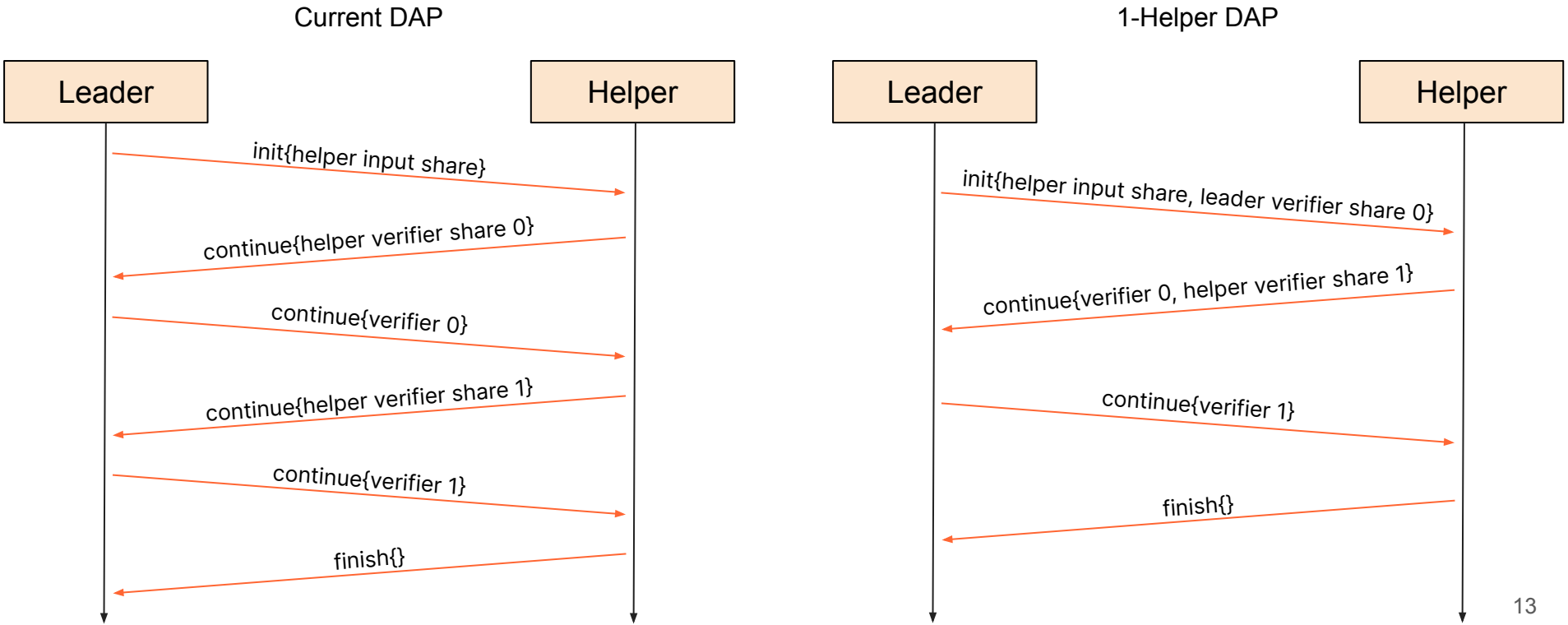
Proposal for 1-Helper DAP

	Current DAP	1-Helper DAP
Aggregation Initialization Comms (non-terminal)	Leader: input share Helper: verifier share	Leader: input share, verifier share Helper: verifier, next verifier share
Aggregation Continuation Comms (non-terminal)	Leader: verifier Helper: verifier share	Leader: verifier, next verifier share Helper: verifier, next verifier share
Network Round Trips	ROUNDS + 1	⌈(ROUNDS + 1) / 2⌉

Example: 1-round VDAF (e.g. Prio3)



Example: 2-round VDAF (e.g. Poplar1)



Summary

- WG decision: **Shall we continue to support multiple Helpers in DAP (needs work) or specialize the protocol for 1-Helper?**
    - Pitch: the aggregation flow will take **about half** as many network round-trips.
- Considerations:
    - #1: Generality (change rules out some use cases for DAP)
    - #2: Complexity (simpler protocol → easier adoption)
    - #3: Current deployments (big change → wait until we have more experience to decide)
    - #4: Scope of DAP draft (one draft to rule them all, or not?)