

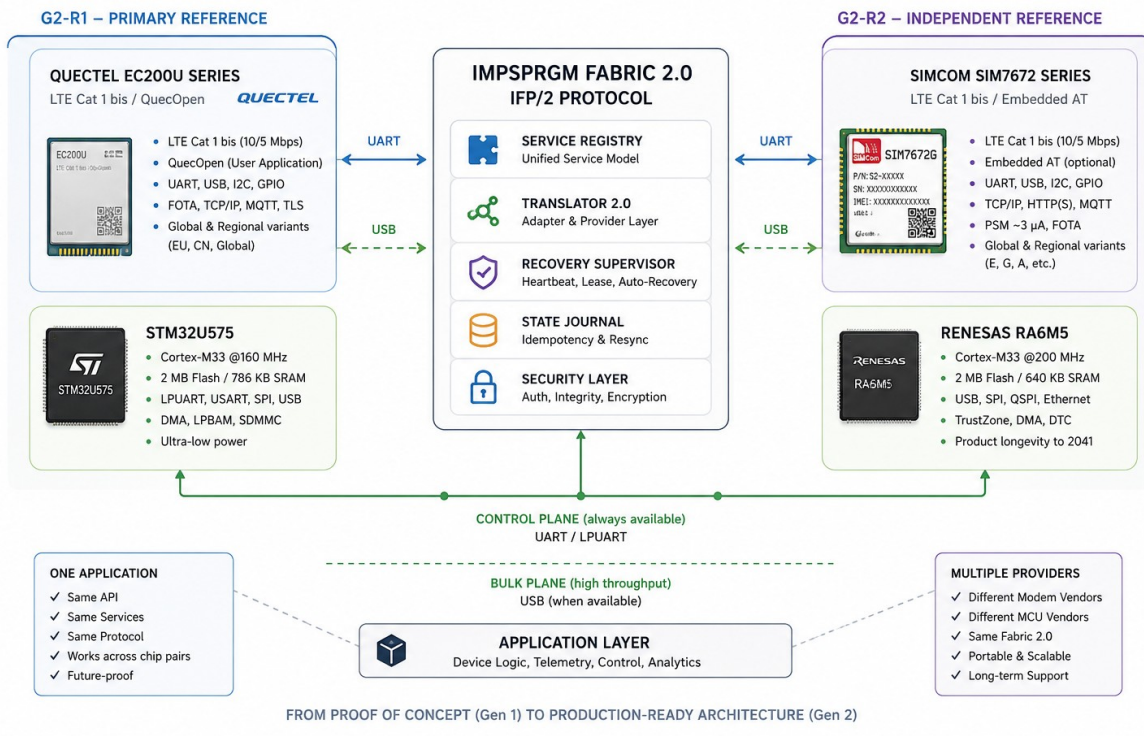
IMSPRGM

FABRIC 2.0 / IFP/2

Second Generation Interprocessor Runtime Protocol Specification v1.0

IMSPRGM FABRIC 2.0 – SECOND GENERATION STACK

One protocol. Universal architecture. Multiple chip pairs.



Generation 2 reference architecture

Status: Protocol specification frozen / Hardware qualification in progress

Engineering specification for autonomous telemetry systems

Version 1.0 | 02 September 2026

Document Control

Field	Value
Document	IMPSPRGM Fabric 2.0 / IFP/2 Protocol Specification
Version	1.0
Release date	02 September 2026
Generation	Generation 2
Protocol status	Frozen for Generation 2 implementation
Hardware status	Qualification in progress
Primary reference	Quectel EC200U Series + STM32U575
Independent reference	SIMCom SIM7672 Series + Renesas RA6M5
Intended domain	Autonomous telemetry, metering, remote control, industrial IoT

Revision history

Version	Date	Change
0.x	2026	Architecture exploration: SIM800C + STM8 lessons, multi-transport concept, recovery model.
1.0	02 Sep 2026	IFP/2 frame frozen; service namespace, state machine, timeout baseline and qualification plan defined.

Publication rule. This document defines the Generation 2 architecture and protocol. Bench-derived throughput, power and recovery figures remain qualification targets until measured and signed off.

Normative language

MUST, MUST NOT, SHOULD, SHOULD NOT and MAY are used as engineering requirement terms. A requirement marked MUST is part of the Generation 2 interoperability contract.

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1. Purpose and engineering objectives

IMPSPRGM Fabric 2.0 is a heterogeneous interprocessor runtime for autonomous telemetry systems. Its purpose is to allow an application to consume resources distributed across different processors without embedding vendor-specific modem or MCU APIs into the application layer.

- Preserve deterministic low-power control on the MCU while reusing communication, storage or compute resources available in the modem or companion processor.
- Make migration from 2G/8-bit designs to LTE/32-bit designs a change of adapters and chip profiles rather than a rewrite of application logic.
- Separate control traffic from bulk traffic so telemetry remains reliable even when large transfers are present.
- Operate with Embedded/OpenCPU modems when available, but remain functional with AT-only or Linux/USB provider modes.
- Detect peer failures, isolate stale remote resources, recover the peer and resynchronize state without operator intervention.

Core principle. Fabric 2.0 virtualizes capabilities, not processor internals. The application asks for a service such as SOCKET, STORAGE or COMPUTE; the provider adapter decides how that service is implemented on a particular chip.

1.1 Non-goals

- No hardware shared-memory requirement between processors.
- No assumption that every modem exposes Bluetooth, filesystem, GNSS, crypto or arbitrary compute APIs.
- No guarantee that optional high-speed transports are available on every reference pair.
- No automatic replay of non-idempotent operations after an uncertain failure.

2. Generation 1 lessons and Generation 2 response

Generation 1 limitation	Generation 2 response
Only SIM800C + STM8 validated	Chip Profile + HAL/Provider Adapter + runtime capability discovery.
Three logical buses multiplexed over one UART	Mandatory UART control plane plus negotiated bulk plane (USB baseline candidate; other adapters optional).
Dependence on SIM800 Embedded AT	Three provider modes: Embedded/OpenCPU, AT-only transaction engine, Linux/USB gateway.
Heartbeat detected failure but recovery was underspecified	Explicit SUSPECT → ISOLATE → RECOVER_PEER → RENEGOTIATE → RESYNC → RUNNING/DEGRADED state machine.
Remote resources could become ambiguous after peer restart	Session-scoped opaque handles and leases; all handles invalidated on session change.

Generation 1 remains the historical proof of the resource-sharing concept. Generation 2 formalizes the concept as an interoperable protocol and runtime contract.

3. Reference platforms and portability model

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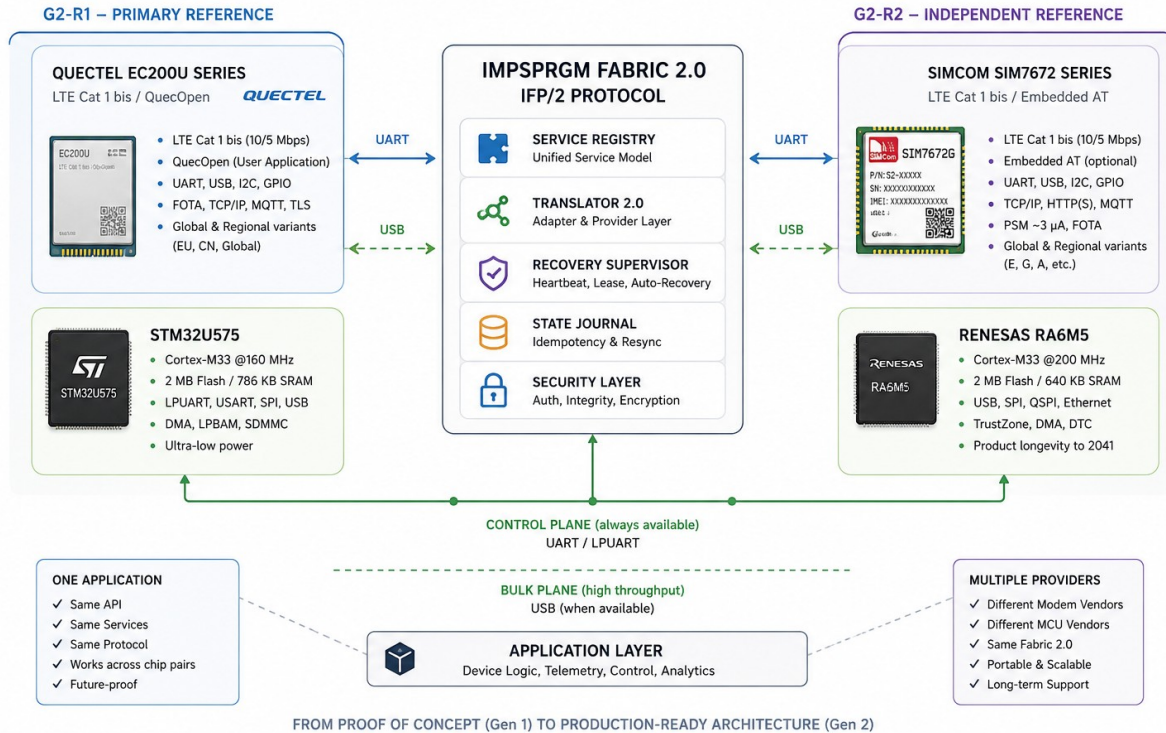


Figure 1. Two independent Generation 2 reference pairs

3.1 G2-R1 Primary Reference

Quectel EC200U Series + STM32U575. The EC200U family is an LTE Cat 1 bis M2M/IoT module family with up to 10 Mbps downlink / 5 Mbps uplink, UART/USB and optional QuecOpen execution environment. STM32U575 is a 160 MHz Cortex-M33 MCU with FPU, up to 2 MB Flash and 786 KB SRAM, suitable for ultra-low-power control and fast transport validation.

3.2 G2-R2 Independent Reference

SIMCom SIM7672 Series + Renesas RA6M5. SIM7672 provides LTE Cat 1, UART/USB and an optional Embedded AT environment with AT compatibility to the SIM800 family. RA6M5 provides a 200 MHz Cortex-M33, up to 2 MB code flash, 512 KB SRAM, USB and high-speed serial interfaces. This pair proves that the Fabric contract is not tied to Quectel or STM32.

Portability acceptance. A second pair is conformant only when the same application service IDs and IFP/2 wire contract work without changing application-level service semantics.

4. Fabric 2.0 architecture

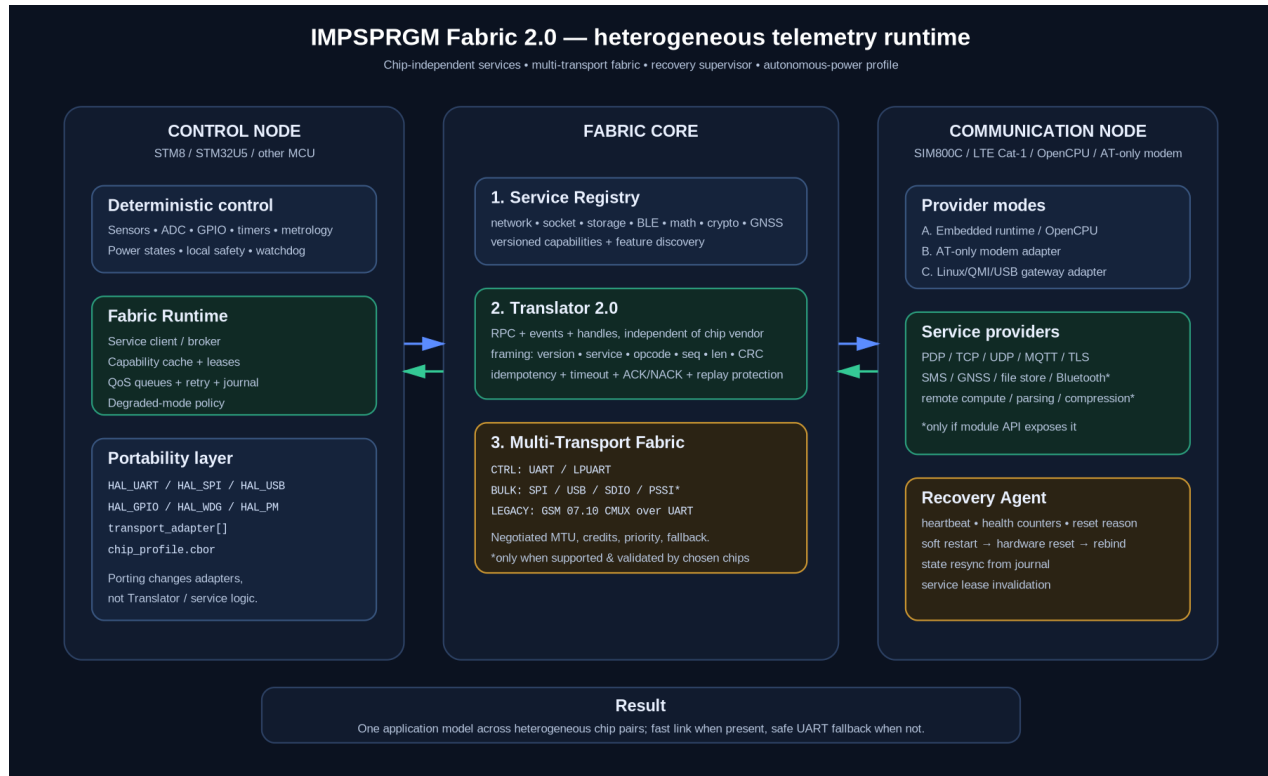


Figure 2. Fabric 2.0 architectural layers

Layer	Responsibility
Application layer	Device logic, telemetry, control and analytics. Vendor-independent.
Service Registry	Versioned capabilities and service discovery.
Translator 2.0	RPC/events, request correlation, payload schemas, retry semantics.
Transport Manager	UART control plane, negotiated bulk plane, credits, segmentation, fallback.
Power Orchestrator	Wake/service/sleep sequencing and low-power policy.
Recovery Supervisor	Heartbeat, leases, peer reset escalation, state resynchronization.
Adapter / HAL	Vendor-specific API and physical interface implementation.

5. IFP/2 transport model

5.1 Control plane

UART/LPUART is mandatory for every Generation 2 implementation. It carries HELLO/CAPS/SELECT/READY, RPC control, events, health and recovery traffic. A conformant implementation **MUST** remain operational over the control plane even when no bulk transport is available.

5.2 Bulk plane

A bulk transport **MAY** be negotiated for large objects such as firmware, logs or large payloads. USB is the initial Generation 2 bulk candidate because both selected modem families and MCUs expose USB capabilities. SPI/SDIO and future transports are adapter classes, not mandatory claims.

Traffic class	Examples	Priority	Transport
P0 Critical	reset, health, safety, wake	highest	UART control
P1 Control	RPC ACK/result, configuration	high	UART control
P2 Telemetry	measurement batches, events	normal	UART or bulk policy
P3 Bulk	FOTA image, large logs	low	negotiated bulk; UART fallback

5.3 Flow control

Bulk transfers use credit-based flow control. A sender **MUST NOT** exceed the receiver-advertised credit window. This bounds receiver memory use and prevents large transfers from starving control traffic.

6. IFP/2 frame format

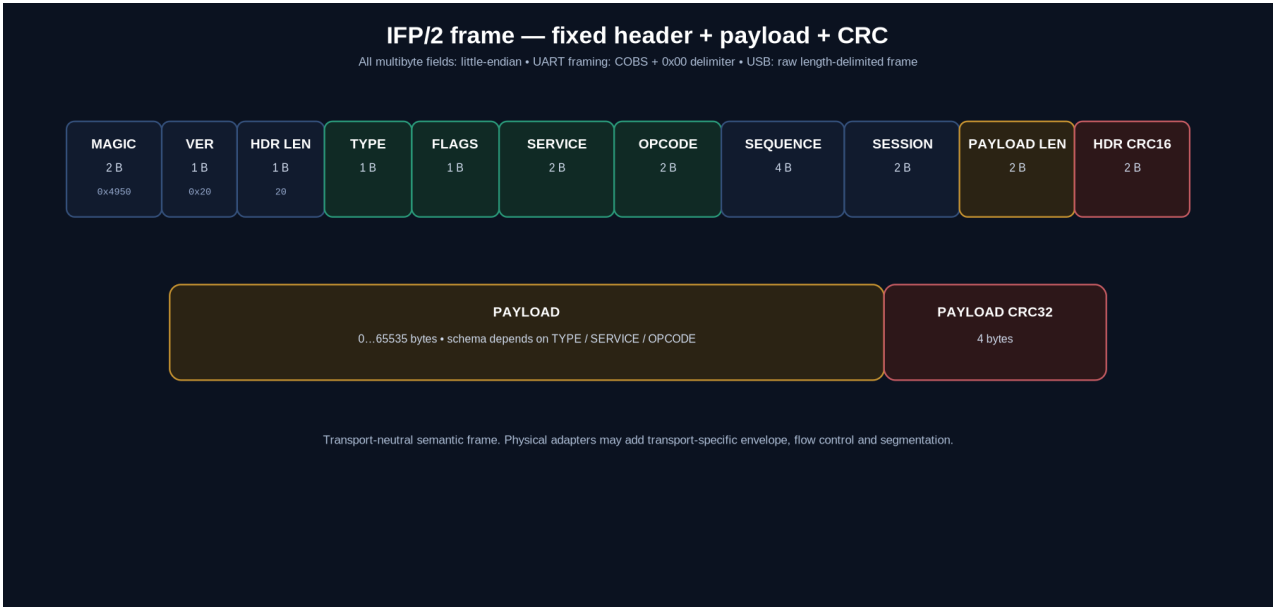


Figure 3. IFP/2 fixed header, payload and CRC

Offset	Size	Field	Rule
0	2	MAGIC	0x4950 ('IP')
2	1	VERSION	0x20 for IFP/2.0
3	1	HEADER_LEN	20
4	1	TYPE	Frame type
5	1	FLAGS	Delivery/behavior flags
6	2	SERVICE_ID	Logical service namespace
8	2	OPCODE	Operation in service
10	4	SEQUENCE	Correlation sequence
14	2	SESSION_ID	Current session
16	2	PAYLOAD_LEN	0..65535
18	2	HEADER_CRC16	Header integrity
20..	N	PAYLOAD	Typed payload
20+N	4	PAYLOAD_CRC32	Payload integrity

6.1 UART envelope

COBS(IFP_FRAME) || 0x00

COBS framing gives deterministic delimiter recovery after malformed or truncated UART data. The IFP semantic frame itself remains transport-neutral.

7. Payload encoding and data types

Generation 2 baseline payload encoding is IFP-TLV. It is deliberately compact, streamable and simple enough for low-memory controllers. Optional CBOR or vendor-native payloads may be exposed only through explicitly versioned extension services.

7.1 TLV structure

FIELD_ID:u16 | TYPE:u8 | LENGTH:u16 | VALUE[LENGTH]

TYPE	Code	Encoding
U8	0x01	1 byte
U16	0x02	little-endian
U32	0x03	little-endian
U64	0x04	little-endian
I32	0x05	two's complement
F32	0x06	IEEE-754 single precision
BOOL	0x07	0 or 1
BYTES	0x08	opaque bytes
UTF8	0x09	UTF-8, no terminator
TLV_SET	0x0A	nested TLV sequence

7.2 Parser requirements

- Unknown FIELD_ID values MUST be skipped using LENGTH unless the enclosing schema marks them critical.
- Unknown TYPE values MUST produce BAD_ARGUMENT or UNSUPPORTED_ENCODING.
- Receivers MUST verify length bounds before accessing VALUE.
- Schemas MUST define mandatory and optional fields per TYPE/SERVICE/OPCODE version.

8. Session establishment and capability discovery

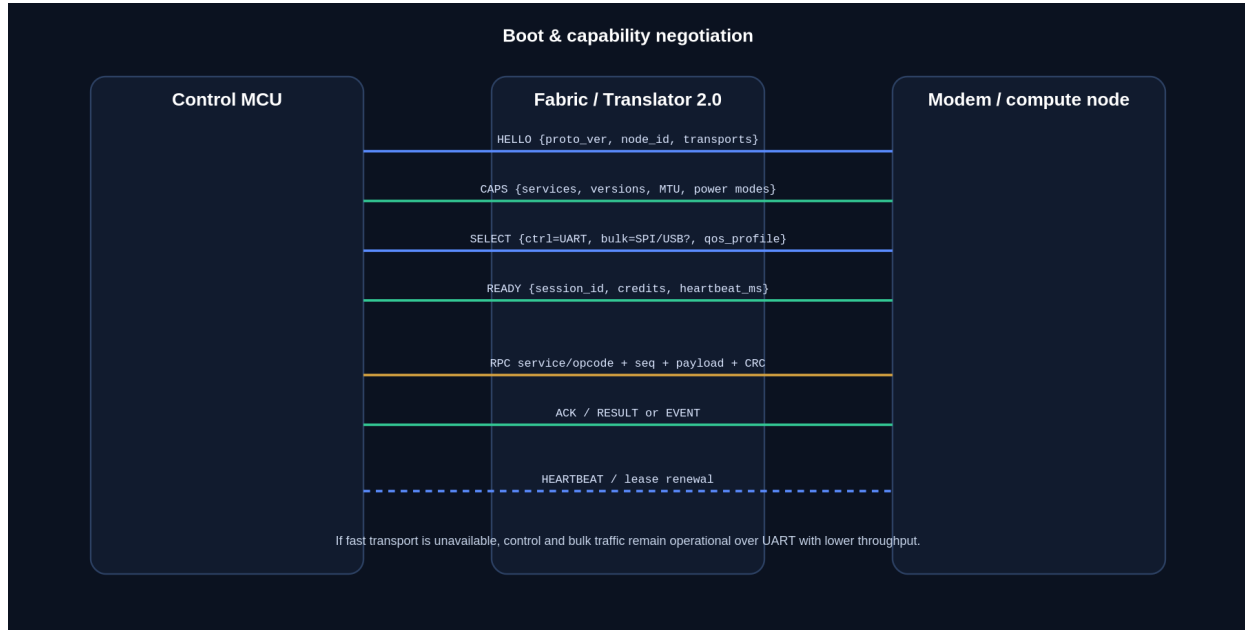


Figure 4. Boot and capability negotiation

Message	Mandatory fields
HELLO	protocol_versions, node_id, transport_bitmap, max_frame_size, boot_nonce
CAPS	service catalog, service versions, transport MTUs, power modes, security profiles
SELECT	chosen protocol version, control transport, bulk transport, QoS profile, security profile
READY	session_id, credits, heartbeat profile, default lease_ms

8.1 Session identity

SESSION_ID is assigned at READY and MUST change whenever either peer restarts or a new negotiation is performed. Any frame carrying an old session ID MUST be discarded. Remote handles are scoped to a single session.

8.2 Capability rules

A service not present in CAPS does not exist for that session. Applications MUST NOT infer capabilities from modem model names. For example, BLUETOOTH or COMPUTE is exposed only if the active provider implements the corresponding service contract.

9. Service registry and core opcodes

ID	Service	Purpose
0x0001	SYSTEM	Platform/version/reset/session
0x0002	HEALTH	Heartbeat and diagnostics
0x0003	POWER	Sleep/wake/power policy
0x0010	TIME	Time source and synchronization
0x0020	LOG	Remote logging and diagnostics
0x0100	NETWORK	Registration/PDP/connectivity
0x0101	SOCKET	TCP/UDP sockets
0x0102	MQTT	MQTT client provider
0x0103	HTTP	HTTP(S) provider
0x0110	SMS	SMS send/receive
0x0120	GNSS	Position/time when available
0x0200	STORAGE	Remote object/file storage
0x0300	BLUETOOTH	BLE/GATT when available
0x0400	CRYPTO	Cryptographic provider
0x0500	COMPUTE	Remote compute jobs
0x0600	FOTA	Firmware update coordination

9.1 Common opcodes

Opcode	Name
0x0001	GET_CAPS
0x0002	GET_STATUS
0x0003	CONFIGURE
0x0004	START
0x0005	STOP
0x0006	RESET

Service-specific opcodes occupy the service namespace. All opcodes are versioned through service capability metadata.

10. Remote handles, leases and transactions

10.1 Opaque handle

A remote resource handle is a 32-bit opaque value returned by a service provider. The consumer **MUST NOT** decode internal meaning from the handle.

REMOTE_HANDLE:u32 // valid only in SESSION_ID that created it

10.2 Lease

Every stateful remote handle has a lease expiration. A lease may be renewed explicitly with LEASE_RENEW or implicitly by a successful handle operation, depending on the service profile.

- On SESSION_ID change all remote handles become invalid immediately.
- On entering SUSPECT the runtime stops allocating new remote handles.
- On ISOLATE all peer-owned leases are invalidated locally.

10.3 Transaction identity

Non-idempotent operations carry a 64-bit TRANSACTION_ID in the payload. A provider **MUST** be able to answer QUERY_TRANSACTION for an implementation-defined retention interval so the caller can distinguish 'not executed' from 'executed but result lost'.

No blind replay. SMS send, actuator commands, destructive storage writes and similar non-idempotent operations **MUST NOT** be automatically repeated after an uncertain timeout unless transaction status proves they were not executed.

11. Error model

Code	Name	Meaning
0x0000	OK	Operation completed.
0x0001	UNSUPPORTED_SERVICE	Service not in active capability set.
0x0002	UNSUPPORTED_OPCODE	Opcode unsupported by service version.
0x0003	BAD_ARGUMENT	Malformed or invalid payload.
0x0004	BAD_STATE	Operation invalid in current service state.
0x0005	TIMEOUT	Operation timed out.
0x0006	BUSY	Temporary busy state.
0x0007	NO_RESOURCE	No buffer/handle/channel/resource.
0x0008	ACCESS_DENIED	Security or policy denied request.
0x0009	TRANSPORT_LOST	Physical transport lost.
0x000A	SESSION_LOST	Session changed or peer restarted.
0x000B	CRC_ERROR	Integrity failure.
0x000C	NOT_READY	Provider not ready.
0x000D	RETRY_LATER	Retry allowed after delay.
0x000E	PARTIAL_RESULT	Valid partial output.
0x00FF	INTERNAL_ERROR	Provider internal failure.

11.1 ERROR payload

ERROR_CODE:u16
 FAILED_SEQUENCE:u32
 RETRY_AFTER_MS:u32 optional
 DETAIL_UTF8 optional

12. Recovery supervisor and degraded mode

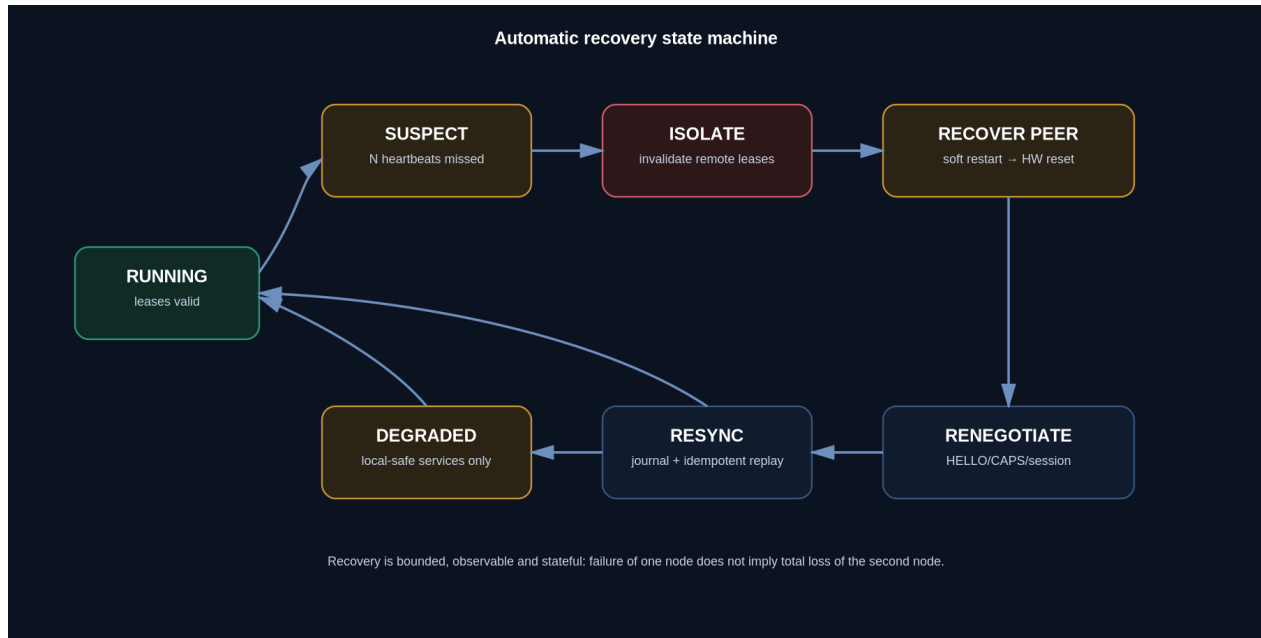


Figure 5. Automatic peer recovery state machine

State	Entry condition	Required action
RUNNING	Healthy session	Normal operation; renew leases.
SUSPECT	Heartbeat/transport threshold exceeded	Stop new handles; issue recovery probe.
ISOLATE	Probe failed or session invalid	Invalidate peer leases and stale handles.
RECOVER_PEER	Peer unavailable	Service restart → runtime restart → HW reset → power-cycle as supported.
RENEGOTIATE	Peer boot detected	HELLO/CAPS/SELECT/READY.
RESYNC	New session ready	Restore journaled idempotent state; query uncertain transactions.
DEGRADED	Recovery exhausted	Keep local metrology/archive/safety/control alive.

12.1 Recovery escalation

1. HEALTH.PING / service status probe.
2. Restart failed remote service if provider supports service-level restart.
3. Restart provider runtime/OpenCPU application.
4. Assert peer hardware reset.
5. Power-cycle peer if the board exposes a controllable rail.

13. Power orchestration

Power state	Peer behavior	Fabric behavior
ACTIVE	Fully operational	Heartbeat active; all capabilities available.
IDLE	Registered/ready with reduced activity	Longer heartbeat; leases retained.
SLEEP	Deep low-power; limited wake sources	No periodic heartbeat; expected_wake_time + lease_deadline used.
OFF	Peer powered down	Remote services unavailable; local degraded mode only.

13.1 Wake batching

The Power Orchestrator SHOULD aggregate remote calls into a service burst: wake peer → negotiate/resume → perform queued work → checkpoint state → return peer to idle/sleep. This minimizes radio/module wake overhead in autonomous battery systems.

13.2 Power-related payload fields

POWER_STATE:u8
EXPECTED_WAKE_MS:u32
MAX_LATENCY_MS:u32
WAKE_REASON_BITMAP:u32

14. Security profile

CRC16/CRC32 provide transmission integrity but are not cryptographic authentication. Fabric 2.0 therefore separates transport integrity from optional authenticated link security.

Profile	Requirement	Use
SEC0	CRC only	Trusted PCB/internal link or qualification bench.
SEC1	Authenticated frames	HMAC-SHA256 truncated tag; key provisioned out of band.
SEC2	Authenticated encryption	AES-CCM-128; nonce derived from boot/session/sequence/direction.

14.1 Key provisioning

- Long-term keys MUST NOT be transmitted in IFP/2 plaintext.
- Provisioning is board/manufacturing specific and outside the IFP/2 wire protocol.
- A security profile is selected during SELECT only if both peers advertised support in CAPS.
- SESSION_ID and SEQUENCE MUST be included in authenticated data to reject replay across sessions.

Scope. Generation 2 interoperability requires SEC0 support. SEC1/SEC2 are defined profiles but become production requirements only when the product threat model requires authenticated interprocessor traffic.

15. G2-R1 implementation profile: EC200U + STM32U575

Element	Profile
Modem	Quectel EC200U Series, LTE Cat 1 bis, up to 10 Mbps DL / 5 Mbps UL.
Execution mode	QuecOpen provider when product variant/firmware permits; AT-only adapter remains supported fallback.
MCU	STM32U575, Cortex-M33 up to 160 MHz, FPU, ultra-low-power family.
Mandatory control	UART/LPUART.
Bulk candidate	USB when the selected board/module interface is implemented and qualified.
Application contract	Same IFP/2 service IDs as G2-R2.

15.1 Provider mapping examples

Fabric service	Quectel provider mapping
NETWORK	QuecOpen or AT network registration/PDP API
SOCKET	QuecOpen socket API or AT socket transaction adapter
MQTT/HTTP	Module protocol API where exposed; otherwise socket-based application provider
STORAGE	QuecOpen filesystem where exposed
GNSS/BLE	Advertise only on variants/firmware that expose capability
COMPUTE	Only project-defined functions implemented by the QuecOpen application

Official Quectel documentation describes EC200U as an LTE Cat 1 bis M2M/IoT family and provides QuecOpen hardware/reference design documents for EC200U variants.

16. G2-R2 implementation profile: SIM7672 + Renesas RA6M5

Element	Profile
Modem	SIMCom SIM7672 Series, LTE Cat 1, up to 10 Mbps DL / 5 Mbps UL.
Execution mode	Embedded AT when supported; otherwise AT-only provider.
MCU	Renesas RA6M5, Cortex-M33 up to 200 MHz, up to 2 MB code flash, 512 KB SRAM.
Mandatory control	UART.
Bulk candidate	USB when board/module interface is implemented and qualified.
Application contract	Identical IFP/2 service IDs and transaction semantics to G2-R1.

16.1 Why this pair matters

The independent reference deliberately changes both modem vendor and MCU vendor. Conformance demonstrates that Translator 2.0, recovery and service semantics are properties of Fabric 2.0 rather than of Quectel/ST SDKs.

SIMCom documents UART, USB, built-in network protocols, filesystem, FOTA and optional Embedded AT for the SIM7672 series. Renesas documents RA6M5 as a 200 MHz Cortex-M33 MCU family with USB and rich serial interfaces.

17. Timing and retry baseline

Event	Baseline	Escalation
UART ACK	150 ms	Retry if policy allows.
Local RPC result	2 s	Query status or retry by idempotency.
DNS	10 s	Abort/retry network policy.
Socket connect	30 s	Network recovery.
HTTP/MQTT operation	30 s	Service policy.
Bulk idle	2 s	Resume/reopen bulk object.
ACTIVE heartbeat	1 s	3 misses → SUSPECT.
IDLE heartbeat	10 s	3 misses → SUSPECT.
Recovery probe	250 ms	Reset escalation.
Software peer restart	2 s	Hardware reset if no boot indication.
Peer boot	10 s	DEGRADED if fail.
Network registration	120 s	Offline/degraded network state.

Tuning rule. These are baseline values for Generation 2 qualification. Products MAY tune them by profile, but changes must not alter protocol semantics or cause non-idempotent replay.

18. Benchmark and qualification plan

Test	Initial acceptance target	Method
UART 115200 application throughput	≥ 8 KiB/s	Long payload loop, control traffic injected.
RPC p95 local service	< 50 ms	10,000 calls under normal load.
USB bulk throughput	≥ 400 KiB/s when supported	Large object transfer, checksum verified.
Continuous traffic	72 h no protocol deadlock	Mixed RPC/events/bulk.
Peer reset cycles	1,000	Random reset during active traffic.
Physical link interruptions	1,000	UART/USB disconnect fault injection.
Full power cycles	500	Cold boot and negotiation.
Non-idempotent duplicates	0	Inject ACK/result loss around transactions.
Protocol resync after peer boot	< 10 s	Reset to READY/RESYNC complete.
Recovery success target	$\geq 99.9\%$ in defined fault set	Automated fault campaign.
Memory stability	No measurable long-run growth	72 h instrumentation.
Power overhead	Measure vs native baseline	Battery/current profiler.

18.1 Fuzz / fault campaign

- 10^7 protocol frames with random valid and invalid payload sizes.
- Random CRC faults, truncation, duplication, delay and reordering at adapter boundaries.
- Random peer resets in every state.
- Session ID rollover and stale handle injection.
- Credit starvation and bulk-flow backpressure.

19. Conformance matrix

Requirement	G2-R1	G2-R2	Qualification status
UART control plane	Required	Required	Implementation + bench
IFP/2 fixed header	Required	Required	Protocol frozen
IFP-TLV parser	Required	Required	Protocol frozen
HELLO/CAPS/SELECT/READY	Required	Required	Protocol frozen
Core SYSTEM/HEALTH/POWER	Required	Required	Implementation
SOCKET service	Required	Required	Implementation
Session-scoped handles	Required	Required	Implementation
Recovery state machine	Required	Required	Bench qualification
DEGRADED local mode	Required	Required	Application integration
USB bulk	Optional/target	Optional/target	Bench qualification
Embedded/OpenCPU provider	QuecOpen profile	Embedded AT profile	SDK/firmware dependent
AT-only provider	Required fallback	Required fallback	Implementation
SEC1/SEC2	Optional	Optional	Product threat-model dependent

19.1 Generation 2 release gate

A hardware pair may be labeled 'Generation 2 Qualified' only after all MUST requirements are implemented and the product-specific qualification matrix is signed off. The protocol itself remains v1.0 unless interoperability semantics change.

20. Implementation checklist

- Implement IFP/2 fixed header encode/decode and CRC validation.
- Implement UART COBS envelope and resynchronization.
- Implement IFP-TLV parser with strict bounds checking.
- Implement session negotiation and service capability registry.
- Implement sequence correlation, ACK/result queues and event dispatch.
- Implement remote handle table and lease expiration.
- Implement idempotency policy and transaction-status query for non-idempotent calls.
- Implement Health/Recovery Supervisor with reset escalation.
- Implement Power Orchestrator and SLEEP semantics.
- Implement AT-only provider baseline before relying on OpenCPU/Embedded AT extensions.
- Instrument counters: frames, CRC errors, retries, resets, lease expirations, recovery times, high-water marks.
- Run automated qualification campaign and archive raw results.

20.1 Metrics to expose

Metric	Type
ifp.frames_tx / ifp.frames_rx	u64 counter
ifp.crc_errors	u64 counter
ifp.retries	u64 counter
ifp.session_resets	u32 counter
ifp.recovery_ms_last / p95	u32 ms
ifp.queue_highwater	u16
ifp.remote_handles_active	u16
ifp.lease_expired	u32 counter

Appendix A. Frame and message examples

A.1 HELLO example

```

TYPE    = HELLO (0x01)
SERVICE = SYSTEM (0x0001)
OPCODE  = 0x0001
SESSION = 0
SEQUENCE = 1

```

TLV:

```

0x0001 U8   protocol_major = 2
0x0002 U8   protocol_minor = 0
0x0003 U32  node_id
0x0004 U32  transport_bitmap
0x0005 U16  max_frame_size
0x0006 BYTES boot_nonce

```

A.2 SOCKET.OPEN example

```

TYPE    = RPC_REQUEST
SERVICE = SOCKET (0x0101)
OPCODE  = OPEN (0x0101)
FLAGS   = ACK_REQUIRED | IDEMPOTENT

```

TLV:

```

protocol = TCP
address_family = IPv4/IPv6

```

RESULT:

```

remote_handle:u32
lease_ms:u32

```

A.3 Non-idempotent SMS transaction

```

RPC_REQUEST SMS.SEND
FLAGS: ACK_REQUIRED
TLV:
transaction_id:u64
destination:utf8
payload:utf8

```

If RESULT is lost:

```

DO NOT repeat SMS.SEND blindly.
Query SMS.QUERY_TRANSACTION(transaction_id).
Replay only if provider confirms NOT_EXECUTED.

```

Appendix B. Reference sources

Quectel EC200U Series product page

<https://www.quectel.com/product/lte-ec200u-series/>

LTE Cat 1 bis family, 10/5 Mbps, IoT/M2M positioning, interfaces and documentation resources.

Quectel EC200U Series QuecOpen Hardware Design V1.0

https://developer.quectel.com/en/wp-content/uploads/sites/2/2024/11/Quectel_EC200U_Series_QuecOpen_Hardware_Design_V1.0.pdf

QuecOpen concept and EC200U variants.

SIMCom SIM7672X Series product page

<https://www.simcom.com/product/SIM7672.html>

LTE Cat 1 family, 10/5 Mbps, UART/USB, network protocols, filesystem, FOTA, optional Embedded AT.

STMicroelectronics STM32U575/585 documentation

<https://www.st.com/en/microcontrollers-microprocessors/stm32u575-585/documentation.html>

STM32U575 device documentation, reference manual, datasheets.

STMicroelectronics STM32U575AI product page

<https://www.st.com/en/microcontrollers-microprocessors/stm32u575ai.html>

160 MHz Cortex-M33, FPU, ultra-low-power MCU family.

Renesas RA6M5 Group Datasheet

<https://www.renesas.com/en/document/dst/ra6m5-group-datasheet>

200 MHz Cortex-M33, memory and interface capabilities.

B.1 Specification provenance

The product capabilities above are source-backed by manufacturer documentation. IFP/2 framing, service IDs, TLV payload model, leases, transaction rules, recovery state machine, timing baselines and qualification thresholds are IMPSPRGM Generation 2 engineering specifications defined in this document; they are not claims made by the semiconductor/module manufacturers.

Final engineering note. Hardware qualification may tune transport MTUs, timing thresholds, power-state parameters and provider-specific capability maps. Such tuning **MUST NOT** change the frozen Generation 2 service semantics without a protocol version change.