

NFC SELECTOR AND FLIP DISPLAY

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Project Proposal for ECE 445, Senior Design, Fall 2026

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18 September 2026

Project No. 17

1 Introduction

1.1 Problem

Users supervising concurrent AI agent sessions must track which projects are running, which need input, and where work last stopped. These sessions execute in their native agent platforms, while project information and notifications are distributed across windows. A missed request can leave a task stalled. Moving to another computer adds a second problem: locating an appropriate saved context and associating it with the correct project and code version.

Research on interrupted work found that participants compensated by working faster while reporting greater stress, frustration, time pressure, and effort [1]. This motivates persistent status cues, but does not establish that our device will improve productivity or health. We aim to make a small working set visible from across a room and provide an explicit reference to previously saved work.

The social relevance includes user control over work records, accessible status information, and continuity across devices. Context may contain private conversation, unpublished code, or third-party information; portability must not remove its access controls. Network dependence, platform differences, material use, noise, and purchase or maintenance costs also affect who can benefit. We will evaluate the prototype without claiming universal color interpretation or complete cross-platform session portability.

1.2 Solution and Current Accomplishments

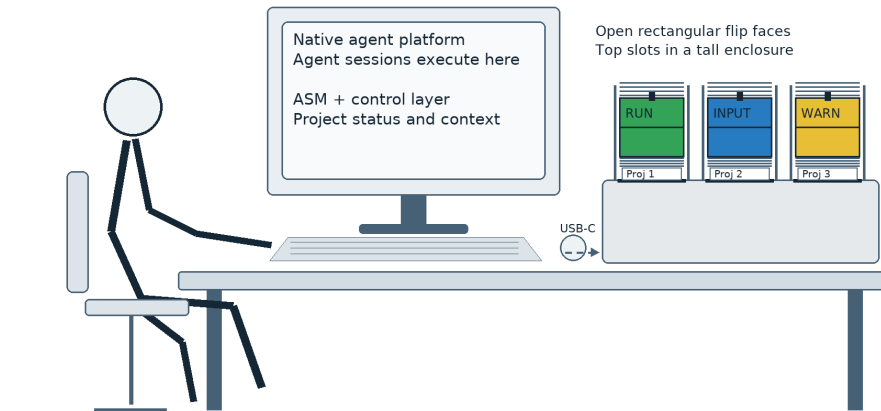
We will build one fixed three-slot desktop peripheral. Small writable NFC tags inside stationary 3D-printed project carriers with press-to-release snap latches will align with three independent mechanical flip indicators arranged horizontally. Agent Session Manager (ASM) will manage projects and status; a companion control layer will connect platform adapters, authorized context storage, and the USB peripheral. Users will continue normal agent interaction in the native platform. ASM will not execute agent sessions.

Each NFC card will hold compact metadata, including a stable project/context key and an immutable context checkpoint head. The cloud will retain versioned context and its project reference. Both references will support diagnosis and recovery; the card is not a copy of the full context or an access credential. The demonstration will use one native platform on two compatible computers and move the same peripheral between computers to show context retrieval and physical status indication. Dynamically attachable slot modules are future work; this prototype has exactly three fixed slots.

Software has progressed from Concurrent Project Manager to ASM and is being adapted to this design. Hardware conceptual design is complete; component research, performance and size definition, and enclosure design are in progress. The course will arrange PCB fabrication. Common passive components and LEDs will be sourced through departmental stock when available; mechanical parts will be designed for campus 3D printing. These are planned resources, not completed fabrication or verification.

1.3 Visual Aid

Computer + three-slot peripheral at the same workstation



Work at the desk; glance at status while reading, taking a break, or doing other tasks.

Target: visible status within about 4-5 m across the room, with a clear view of the display.

Figure 1 A seated user works at a desk with a computer, monitor and the three-slot device: open flip drums above, with vertical NFC slots and short project-name tabs in front. Native platforms execute sessions; ASM and its control layer manage status and context. The device offers an at-a-glance view during desk work and other activities in the room. Conceptual drawing, not to scale.

The five printed colors indicate Running (green), Warning (yellow), Error (red), Waiting for user input (blue), and Blank (white). Users can glance at the device while reading, taking a break, working with another agent, or doing assignments, creative work and document editing. The target is status recognition within about 4-5 m across the room wherever the display is in clear view, without continuously checking individual sessions on screen. Project names need not be readable at that distance.

1.4 High Level Requirements

These are proposed acceptance targets, not measured results. H2 uses a provisional 15 s target for the selected geared motor; faster operation requires loaded testing.

- H1. The device shall maintain three concurrent card-to-project-to-display bindings, detect at least 98% of insertion and removal events across 100 insertion/removal cycles per slot, and produce zero wrong-slot project assignments in those tests.
- H2. Each slot shall reach the correct stable display state within 15.0 s for at least 95% of 100 commanded transitions, measured from control-layer receipt of a valid event; tests shall include concurrent changes on all three slots and all ordered pairs of the five states.
- H3. Each of at least three consenting team testers shall correctly identify at least 95% of 60 randomized slot-state presentations at 5.0 m under 300-500 lux and horizontal viewing angles of 0 and ± 30 degrees; the same procedure shall also pass at 4.0 m. Project-name readability is not required at those distances.

2 Design

2.1 Block Diagram

Host and cloud interfaces

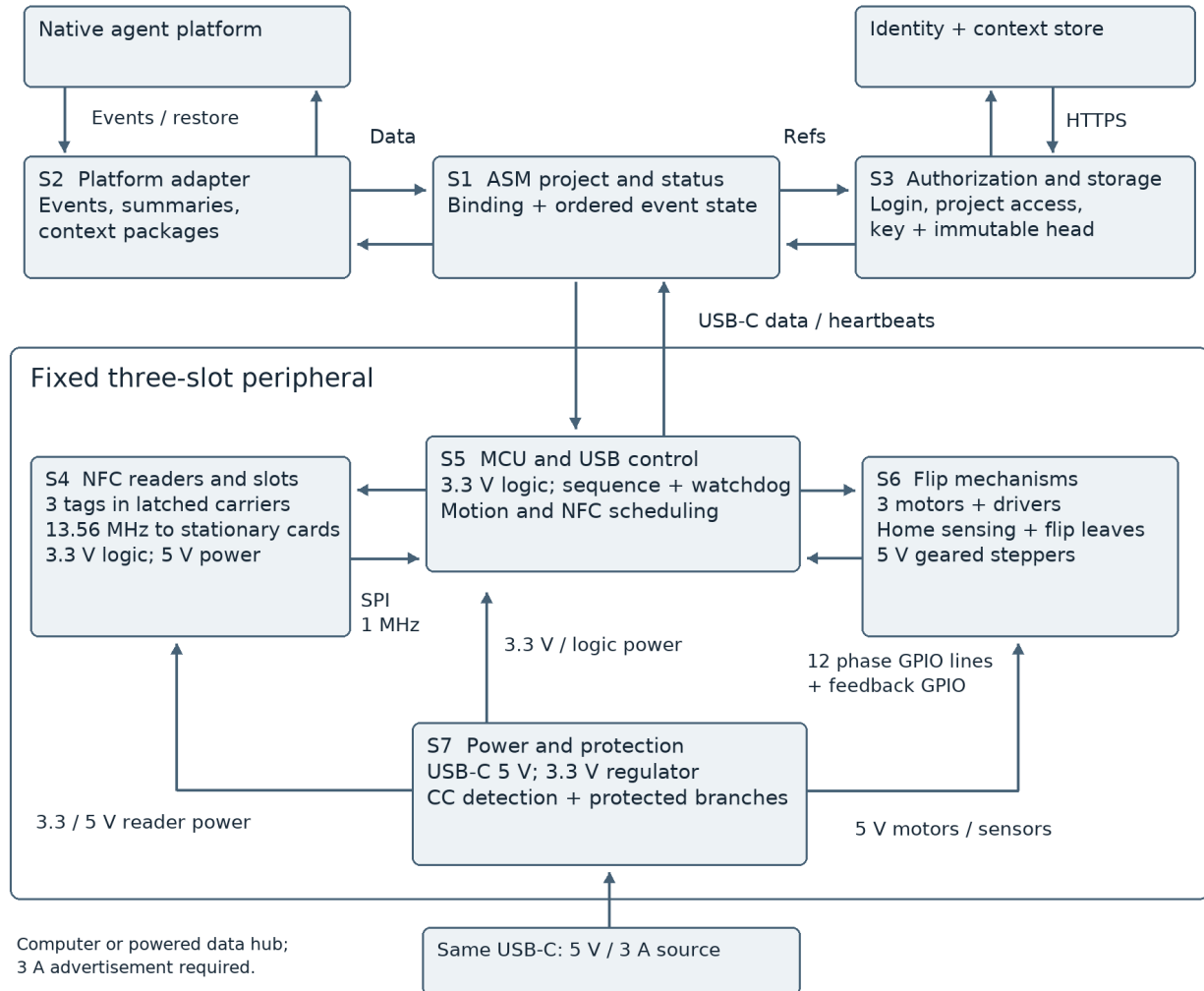


Figure 2 Seven logical subsystems and their interfaces. One USB-C cable carries USB data and 5 V power from a qualified computer port or powered data hub advertising 3 A. Voltage and bus labels are proposed engineering targets to be reconciled with component selection. All hardware shares ground; motor return routing is separated from sensitive reader circuitry.

S1-S3 form the host management and control layer. S4-S7 form the peripheral. The external agent platform and cloud services are dependencies rather than agent execution provided by ASM. The custom PCB will integrate control, power, driver and reader interfaces; NFC matching circuitry will follow the selected reader reference design.

2.2 Host Subsystems

S1 ASM Project and Status Management

ASM maps slots to projects and native sessions, receives events from S2, exchanges references with S3, and commands S5. Separate binding, runtime, synchronization and observed-display states support H1 and H2.

- Every display command shall include slot ID 0-2, project ID, binding generation, event sequence and target state. Removal or rebinding shall invalidate the previous generation; stale and duplicate commands shall not actuate a replacement project.
- Heartbeats shall occur at least once per second; three missed heartbeats shall mark the connection stale. Synchronization errors shall remain separate from execution status.
- A deterministic test shall interleave at least 1,000 events across three projects, including duplicates, reordering and card replacement, with zero wrong-slot commands.

S2 Platform Adapter and Checkpoint Builder

The adapter maps native events to display states and packages authorized summaries and records for S3. It supports H2 and prepares context for a native session on the second computer, without recreating an opaque live process.

- The demonstration shall integrate one native platform on two computers. State mapping shall be documented; an unsupported or ambiguous event shall not be reported as confidently Running.
- Each checkpoint manifest shall include project identity, capture time, source platform, summary, task state and available code repository/branch/commit references. Uncommitted or unuploaded code shall be identified as incomplete unless explicitly included in the authorized package.
- Automated capture shall use a configured end-of-work trigger; a manual trigger shall exercise the same path during testing. Ten two-computer round trips shall retrieve the intended checkpoint and project records without a version mismatch.

S3 Authorization and Context Storage Access

S3 authenticates users, checks project access, commits private context, and resolves card references. Cloud and NFC references support H1 and recovery; neither duplicates the context payload.

- Context access shall require both a valid authenticated identity and project authorization. Ten unauthenticated and ten wrong-project requests shall disclose no context payload; a readable card UID or key alone shall not authorize access.
- The system shall confirm cloud commit success before offering its head for card write-back. Cloud-save and card-sync outcomes shall be reported separately, retaining the last verified reference on failure.
- If card and cloud references disagree, both shall be retained for review. Automatic precedence and reconciliation policy remain design decisions; the prototype shall not silently overwrite either reference.

2.3 NFC and Embedded Subsystems

S4 NFC Read Write and Fixed Slots

Three keyed, 3D-printed carriers contain small NFC tags. A resilient latch engages on insertion and releases when pressed, similar to a network-plug latch. Fixed stops locate each tag relative to its reader antenna; the latch retains the carrier rather than positioning the flip mechanism. Reader channels identify and update metadata without moving the carriers. Only the selected reader field will be active during a transaction to reduce adjacent-reader interaction. Reader modules support early testing; the final reader IC, antenna and matching network must be checked for custom-PCB feasibility. S4 supplies physical identity for H1.

- The proposed reader interface is SPI at 1 MHz with separate chip selects and required IRQ/reset signals at 3.3 V logic. The reader power rail will be 3.3 V or the protected nominal 5 V branch as selected; a shared bus does not by itself prevent RF cross-reading.
- The initial metadata budget is at most 400 bytes including framing and integrity fields, targeting a tag with at least 504 bytes of user memory [2]. Worst-case serialization shall be measured before the tag is frozen; full URLs, transcripts and code remain off-card.
- Each write shall be followed by complete read-back and field/integrity checks. Card removal during a write shall leave an explicit invalid or pending record, never an apparently successful new binding.
- Each carrier shall complete 100 insertion and press-release cycles without latch fracture, accidental release or loss of read alignment. Tag size, wall thickness, insertion depth and antenna spacing shall be validated together; smaller tags are not assumed to retain full-size card read range.
- Insertion/removal detection shall complete within 1.0 s during polling with adjacent slots occupied. At least 100 cycles per slot shall establish H1 performance with motor activity included. Reader field on/off timing and slot spacing require measurement.

S5 MCU Communication and State Control

The MCU bridges USB messages, NFC transactions, actuator drivers and sensor inputs. It schedules the three slots and reports requested, moving, completed and failed motion separately. The host provides project meaning; embedded firmware enforces physical slot addressing, timing and fault handling for H1-H3.

- The USB CDC application protocol shall use framed messages of at most 512 bytes with sequence numbers and integrity checks. Command acknowledgement shall arrive within 100 ms during normal operation; acknowledgement shall not claim that motion has finished.
- Sensor and driver interfaces shall use 3.3 V-compatible GPIO. A preliminary allocation reserves a shared SPI bus, three reader selects, reader control lines, twelve phase-control outputs, three home inputs and branch-enable/power-status lines; the final MCU requires a pin-budget check.
- The revised H2 budget allocates 0.35 s to host/USB/queue handling, 13.65 s to movement including ramping, and 1.00 s to settling/feedback. Three-slot scheduling must satisfy this budget rather than serializing full movements without accounting for delay.
- Motion timeout shall disable the affected driver and report a fault. Reset shall invalidate the known position and require homing before normal display claims resume.

A serial monitor or host diagnostics view will show hardware failures and stale data without adding a sixth flip color. An auxiliary validity indicator and a power-loss treatment remain necessary design details because a mechanical page can retain its last appearance after power is lost.

2.4 Mechanical and Power Subsystems

S6 Flip Mechanisms and Position Feedback

Each slot has an open flip assembly above a tall rectangular enclosure containing the PCB, NFC electronics and drive motors. Enclosure height is roughly the visible flip-face height. A thin rectangular NFC holder of comparable height inserts vertically through a front top-panel slot, broad face toward the user and short bottom edge first. Its latch locks automatically; pressing the flexible tab releases it. Only a project-name strip remains exposed below the display. Upper leaves meet a stop; released leaves hang under gravity. S6 provides H2 and H3 output.

- The first geometry target is an exposed color area of at least 80 mm by 60 mm per slot and a center pitch of at least 100 mm. These are prototype starting dimensions, not evidence that H3 is met; NFC spacing may require a larger pitch.
- A five-position carrier shall index nominally in 72-degree increments. The preliminary actuator path uses the TS-24BYJ48A-25 5 V four-phase geared stepper with four low-side switching channels per motor [8]. The firmware shall use the specified 1-2 phase sequence, with at most two phases energized per motor. The initial loaded operating point is 100 pps; torque and timing shall be verified under Section 2.6 assumptions.
- Each unit shall home at startup and after a motion fault. Home sensing plus counted steps estimates carrier position; visible leaf identity shall be checked independently during verification because a shaft at the correct angle does not prove a leaf released.
- Each slot shall complete 100 full cycles through all five states without a jam or wrong final leaf. Tests shall include power interruption and an intentionally blocked mechanism, followed by bounded stop and recovery.
- The top remains visually open; local guards shall cover accessible axle, gear and drive pinch points without hiding status leaves. The exposed project tab shall not occlude the status face at seated viewing positions or H3 test angles, and shall remain outside the entire leaf swept volume. A powered validity indicator shall distinguish a live display from a stale retained page; users shall treat an unpowered device as invalid. A passive invalid marker is a candidate if this cue is insufficient.

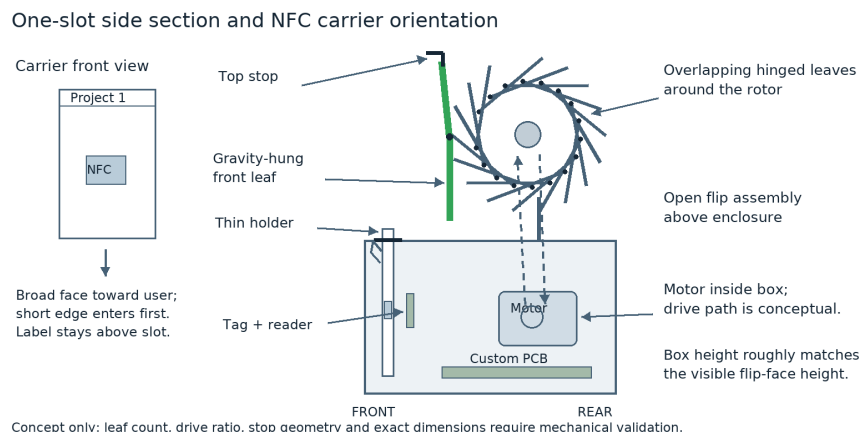


Figure 3 Compact side section and carrier front view. Hinged leaves overlap around the rotor; a top stop retains the upper leaf and the front leaf hangs under gravity. The tall base houses electronics and motors. The thin NFC holder inserts almost fully, leaving only its project label exposed. Drive geometry is provisional.

S7 Custom Five Volt Power Distribution

One USB-C receptacle supplies both USB 2.0 data to S5 and nominal 5 V VBUS to a custom distribution PCB. The selected computer port, or a powered data hub connected to it, must advertise 3 A at 5 V. A wall charger alone cannot carry host data. No separate DC barrel input, motor boost rail or 12 V supply is used. A Type-C sink controller detects attachment and advertised current; a protected load switch distributes power to separately routed motor, NFC and logic branches [9].

- The full operating mode shall be enabled only after the sink detects a 3 A source. CC termination alone does not authorize 3 A. Before qualification, motor and RF loads shall remain disabled; startup, enumeration and suspend current shall respect the applicable USB power rules. Unsupported sources shall not start full operation.
- The connector-level design budget is at most 10 W, approximately 2.0 A at nominal 5 V. This is an allocation requiring measurement, not a measured maximum. VBUS capability detection is not a current limiter: separate protection shall limit fault current and inrush within source, connector and trace ratings.
- The proposed acceptance range at the board input is 4.75-5.25 V with the chosen source and cable under load. Branch drop shall be at most 0.25 V; motor/reader electronics must be qualified over the resulting 4.50-5.25 V distribution range. This input range is a project qualification condition, not a guarantee for every USB-C source. The 3.3 V rail shall remain within $\pm 5\%$.
- The PCB shall provide input ESD/transient protection, reverse-current blocking where required, controlled inrush, local decoupling, inductive recirculation and protected motor branches. A 5 V-to-3.3 V regulator supplies logic; readers may use protected 5 V power with 3.3 V digital interfaces after datasheet checks. Motor return currents shall not share sensitive NFC routing.
- During 100 simultaneous three-slot transitions and a bounded blocked-mechanism test, record input power, all rails, coil current, temperature, resets and NFC errors. Input power shall remain within the 10 W budget and source limits, with zero supply-induced resets or wrong-slot reads. Source removal, insufficient-current sources and host suspend shall disable actuation and invalidate the live-display cue.

Power Budget at the USB C Input

The following allocations include all three slots and are engineering ceilings to verify: motor/driver branches 2.0 W; three powered NFC channels with only one RF field enabled 4.5 W; MCU, USB and 3.3 V conversion 1.0 W; sensors and validity indicators 0.5 W; input protection and distribution losses 0.5 W; unallocated contingency 1.5 W. Total: 10.0 W. The NFC, logic and sensor allocations are not vendor maximum-current claims and must be replaced or validated by the final BOM.

A nominal 5 V $\times$ 3 A source provides 15 W, leaving 5 W against the planned 10 W load. At a qualified board input of 4.75 V, 10 W corresponds to 2.11 A, still below 3 A. Cable loss reduces delivered voltage and available board power; the selected cable and source must pass the loaded-input test. Higher-voltage USB PD negotiation is not needed for the chosen 5 V Type-C-current path [9].

2.5 Metadata and Context Transfer

The card stores a stable key and an immutable context head together. Proposed fields are `schema_version`, `project_key`, `actor_ref`, `checkpoint_at`, `context_store_ref`, `context_head` and `card_revision`, plus an integrity field. The key locates a project in the authorized control plane; the head identifies a specific saved context. Neither field is a cryptographic secret. Longer code references and the complete context manifest stay in cloud storage.

Code commit and context head are distinct. The former identifies source-code history; the latter identifies saved working context and its code references. A local unpushed change is not made portable merely by writing its commit ID to the card. Recovery can use either verified reference to investigate a mismatch, but reference duplication cannot recover a deleted cloud payload. Priority and reconciliation rules will be decided later; conflicts remain visible and require review.

2.5.1 Cross Device Workflow

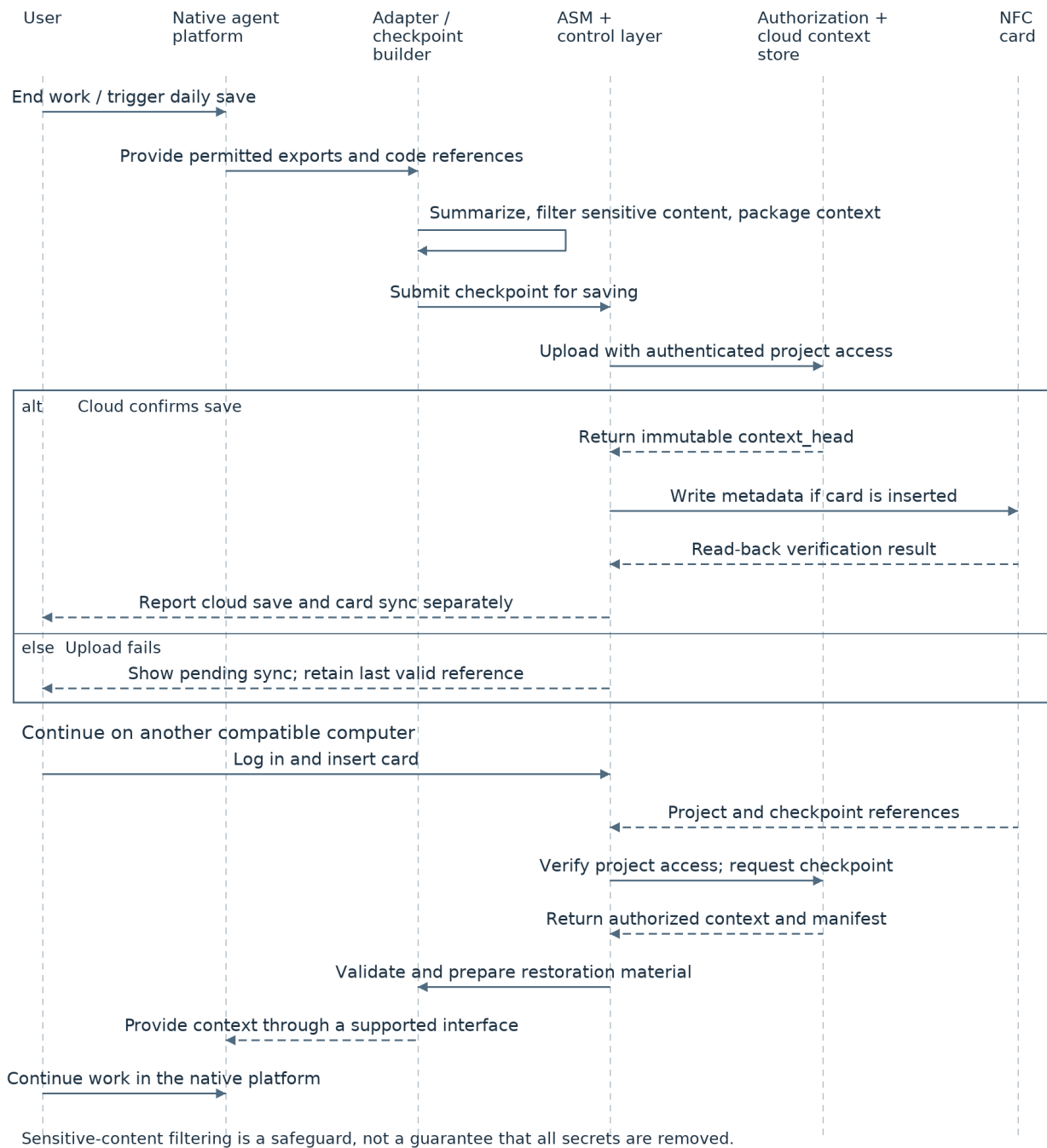


Figure 4 Checkpoint saving and cross-device continuation. Solid arrows show requests; dashed arrows show responses. The alternative branches separate successful cloud saving from upload failure. Card synchronization and destination authorization are explicit.

2.6 Tolerance Analysis

The selected TS-24BYJ48A-25 introduces a coupled risk: geared motion may be slow, and cable plus driver voltage drop may reduce torque. The following calculations use its supplied drawing [8]. They establish test conditions and limits, not proof that the assembled mechanism meets H2.

Motor Current and Power

Assume the specified 120 ohm $\pm 10\%$ resistance at 25 C applies from the common wire to each phase; verify this on the actual motor. At nominal 5 V, one phase draws $5/120 = 41.7$ mA. With at most two phases on in each of three motors, $P = 6 \times 5^2/120 = 1.25$ W. At 5.25 V and 108 ohm, the static bound is $6 \times 5.25^2/108 = 1.53$ W. Lower-temperature winding resistance and driver/control consumption require measurement; a provisional 2.0 W motor-branch allocation leaves margin over this 25 C tolerance calculation.

The five-wire common-terminal topology requires four low-side phase switches per motor, rather than a bipolar STEP/DIR driver. ULN2003LV is a candidate with 3.3 V-compatible inputs and inductive recirculation [10]; final checks include voltage drop, total package dissipation and turn-off transients. A shorted winding is a fault outside the normal budget and must trigger protection. Blocking the geared output does not imply the startup-current model of a brushed DC motor; timed shutdown is still needed for heating and mechanical safety.

Travel Time and Torque

Using the stated $5.625^\circ/25 = 0.225^\circ$ output increment, nominal output resolution is 1,600 increments per revolution. A 72° state interval requires 320 increments and the longest forward transition requires 1,280. At 100 pps it takes 12.8 s before ramping and settling, motivating the provisional 15 s H2 target. Confirm pulse-to-angle mapping with the specified 1-2 phase sequence. The listed 600 pps minimum pull-in rate is not a loaded speed-torque curve and does not establish the previous 2 s goal.

The specified minimum pull-in torque is 200 gf cm = 0.0196 N m at 100 pps and 5 V terminal voltage. For a lightweight carrier, assume effective unbalanced mass 0.005 kg, radius 0.040 m, friction 0.004 N m, and inertia 8×10^{-5} kg m². At 100 increments/s, output speed is 0.393 rad/s. A 0.2 s ramp gives $\alpha = 1.96$ rad/s². Required torque with a factor of two is $2 \times (0.005 \times 9.81 \times 0.040 + 0.004 + 8 \times 10^{-5} \times 1.96) = 0.0122$ N m. These are design assumptions to measure, not demonstrated reductions from the earlier mechanism.

The nominal rating exceeds that illustrative load, but at a 4.50 V branch and a hypothetical 0.20 V switch drop the winding sees only 4.30 V, outside the 5 V torque test condition. Therefore the 0.0196 N m guarantee cannot be carried over. Measure loaded pull-in and repeated flips at the lowest qualified voltage; reduce friction or mass, lower speed, or revisit the motor if margin fails. Doubling assumed friction gives about 0.0202 N m with margin, exceeding the nominal rating and illustrating the principal risk.

Geometry and Verification

An 80 mm color width at 5 m subtends approximately 0.92 degrees; this is angular size, not proof of color recognition. H3 requires tests with actual colored leaves. Validate latch fatigue, insertion depth and small-tag RF alignment separately from leaf release. The carrier latch retains the NFC tag; it does not lock the flip mechanism or justify assuming zero motor holding power. Coil release after motion is allowed only if the displayed leaf remains stable in tests.

3 Ethics Safety and Societal Impact

3.1 Context Privacy Ownership and Authorization

Our central ethical concern is preserving users' control over context as it moves between machines and, in future work, between agent platforms. A context package may include private discussion, unpublished source code, personal information or material owned by collaborators. Being able to export it does not establish permission to copy or disclose every included item. The IEEE Code of Ethics connects professional responsibility with privacy, honest communication and awareness of technology's consequences [3].

We will limit capture to an explicitly configured project and a user-authorized set of records. The host will explain what is retained, where it is uploaded and who has access. Automated summarization will use this configured scope; it will not be treated as guaranteed removal of secrets. Credentials and unnecessary personal identifiers will be excluded from card records and context packages, and demonstration data will be synthetic or team-approved. A pseudonymous actor reference can identify a work record without placing a person's name on a readily readable card.

The card will contain locators, not authentication secrets. A destination computer must authenticate the user and check project permission before retrieving a checkpoint. Card loss, copying or a malformed reference must not bypass this control. Uploaded records will remain private to authorized project members; retention, deletion and revocation behavior will be documented, including the limits of deleting material already copied to another authorized device. We will not claim that a portable summary transfers platform ownership rights or reproduces an entire native session.

3.2 Integrity and Responsible Use

Accidental stale references and intentional card tampering can select the wrong version or project. The control layer will validate project association and context integrity, and show conflicting card/cloud heads instead of silently reconciling them. A key and head provide redundant references, not two independent context backups. Running means an observed execution state, not a guarantee that the agent's output is correct. Physical indications may remain after power loss, so the validity cue and host diagnostics must communicate that limitation. We will distinguish test results from design targets in accordance with IEEE expectations for truthful technical claims [3].

3.3 Safety and Applicable Guidance

Development hazards include exposed wiring, soldering, short circuits, hot drivers and moving parts. We will follow course and laboratory procedures, de-energize circuits before rewiring, guard pinch points, protect motor branches, qualify the USB-C source and cable, stop on bounded motion faults, and use strain relief and protected low-voltage distribution. UIUC Division of Research Safety guidance addresses equipment condition, electrical hazards and safe laboratory work [4]. The device is an awareness aid, not a safety-critical alarm or control interlock.

IEC 62368-1 provides a relevant safety framework for information and communication technology equipment, organizing safeguards around energy-related hazards [5]. We will use its public scope to guide hazard review and consult accessible applicable requirements as the design develops; we do not claim product certification. For the 13.56 MHz NFC path, reader and antenna choices must be checked against applicable FCC Part 15 requirements, including 47 CFR 15.225 [6]. A purchased reader module does not by itself prove compliance of a modified antenna or complete device.

3.4 Societal Economic and Environmental Effects

Persistent physical status may help users decide when to return to a workstation, while authenticated context retrieval may reduce the effort of changing computers. These are intended benefits, not demonstrated health or productivity outcomes. Platform export restrictions, account requirements, network access and the cost of the peripheral can limit adoption. The initial evaluation therefore covers one platform and two configured machines rather than promising universal compatibility.

Color meanings vary, and color-only signals may exclude some users. The five-color baseline will be reinforced with readable nearby labels; redundant symbols or patterns can be evaluated without changing the palette. Testing will document the illumination, distance and participant scope rather than generalize three team members' results to all users. Mechanical noise and unnecessary page changes will also be considered when choosing the motion policy.

We will use campus printing and course PCB fabrication, reuse available common parts, and design serviceable leaf carriers and replaceable electronics where practical. Printed plastic and electronics create a material burden; low holding power alone does not establish a favorable lifecycle impact. We will separate reusable components and use appropriate institutional disposal channels. Illinois EPA guidance describes recycling obligations for covered electronic device categories; applicability to this prototype must be checked rather than assumed [7]. Future modular expansion may improve reuse, but hot-pluggable slots are outside this project stage.

References

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