Contents

1 US Payroll Platform — Product Specification

Version: 0.1 (repository-derived) Date: 2025-12-16

1.1 1. Executive summary

US Payroll Platform is an enterprise-focused, Kotlin/JVM (Spring Boot) monorepo that implements a functional-core payroll engine surrounded by production-minded services for HR data, tax content/catalogs, labor standards, payrun orchestration, payment initiation, reporting, and filings.

Core product intent:

- Provide deterministic, testable paycheck calculations via a framework-agnostic domain library (`shared-kernel` + `payroll-domain`).
- Provide operationally safe payroll execution workflows via service boundaries (idempotency, outbox/inbox, DLQ replay/reconciliation).
- Allow statutory content (tax and labor rules) to be curated and updated as versioned artifacts in Git (CSV/JSON/SQL), with deterministic generation and validation.

Status and caveats:

- The repository is in active development and contains both implemented services and placeholder modules.
- Tax and labor content is primarily oriented around the 2025 ruleset, with explicit playbooks and pipelines for yearly updates.

1.2 2. Problem statement and purpose

Payroll correctness requires the intersection of:

- Employee facts (home/work jurisdiction, compensation, elections)
- Statutory rules (federal/state/local withholding, wage bases, caps)
- Labor standards (minimum wage, overtime thresholds, tip credit rules)
- Employer-specific configuration (earnings/deductions plans, overlays)
- Operational guarantees (retries, idempotency, auditability, traceability)

This repository's purpose is to deliver a platform foundation that can compute paychecks deterministically and execute high-volume payruns safely, while supporting governance workflows for rapidly changing statutory content.

1.3 3. Intended users and stakeholders

Primary users:

- Payroll product and engineering teams building an internal payroll system.
- Operations/Compliance teams performing yearly statutory updates and audits.
- SRE/Platform teams operating multi-service deployments and incident workflows.

Secondary users:

- Downstream reporting/filings consumers that build projections from stable ledger events.
- Integrations teams implementing payment rails or exporting data.

1.4 4. Scope

1.4.1 In scope

- Paycheck calculation and explainability (trace).
- Payrun orchestration (queue-driven finalization, idempotency keys, reconciliation helpers).
- Statutory content pipelines:
  - Tax content: CSV → JSON → DB catalog.
  - Labor standards: CSV → JSON + SQL.
- Payment initiation workflows with an explicit provider integration seam.
- Reporting/filings "shape" computations and ledger event contracts.
- Production-oriented operational controls: outbox/inbox, DLQ replay, SLO guidance, and security boundaries.

1.4.2 Out of scope (current)

- A full enterprise-grade identity platform is not implemented in this repository (an `identity-service` module exists but is currently empty).
- Nationwide completeness for all state/local edge cases is explicitly a work in progress.

1.5 5. Key capabilities

1.5.1 5.1 Payroll calculation (functional core)

Core characteristics:

- Pure calculation logic expressed as functions over immutable domain types.
- No direct dependency on HTTP, databases, or Spring.
- Rich "explainability" via `CalculationTrace` and typed trace steps.

Core inputs/outputs:

- Inputs: `PaycheckInput` composed of `EmployeeSnapshot`, `PayPeriod`, `TimeSlice`, `TaxContext`, `YtdSnapshot`, labor standards context, and optional garnishment/support contexts.
- Outputs: `PaycheckResult` including earnings/taxes/deductions totals and trace.

Supported employee and pay types (repository-derived):

- Base pay models:
  - Salaried (annual salary allocated to a pay period based on pay frequency/schedule; supports optional proration).
  - Hourly (hourly rate multiplied by regular hours; supports separate overtime hours).
- Work patterns:

  - Full-time vs part-time is not a distinct enum in the domain; it is effectively represented by the employee's base pay model (salary vs hourly) plus the provided hours/proration for the period.
  - Shift work is represented via hours and additional earnings rather than a dedicated "shift" type.
- Overtime:
  - Hourly overtime is supported via `TimeSlice.overtimeHours` and an `OvertimePolicy` (default multiplier 1.5; can be configured per employer earning definition).
- Tipped employees:
  - The domain models tipped employees via `EmployeeSnapshot.isTippedEmployee` and can enforce a minimum-wage "tip credit make-up" using `LaborStandardsContext` (federal baseline in-domain, with state/local standards supplied by labor-service).
- Supplemental/variable earnings:
  - Arbitrary additional earning lines can be supplied per period (`TimeSlice.otherEarnings`) and categorized (BONUS, COMMISSION, HOLIDAY, TIPS, etc.).
  - Off-cycle runs are modeled by setting `TimeSlice.includeBaseEarnings=false` and providing only the explicit earning lines.
- Tax-relevant employment classifications:
  - `EmploymentType` supports REGULAR, HOUSEHOLD, ELECTION_WORKER, AGRICULTURAL for certain tax rule differences.

Key domain subsystems (representative):

- Earnings calculation
- Tax basis computation + tax rule application
- Deductions/benefits with tax effects (pre-tax vs post-tax)
- Year-to-date accumulation

Primary location:

- `payroll-domain` (models under `com.example.uspayroll.payroll.model.*`, orchestration under `com.example.uspayroll.payroll.engine.*`)

1.5.2 5.1.1 Garnishment & support withholding subsystem

This repository includes an explicit garnishment calculation subsystem in the payroll domain plus HR-service endpoints for sourcing orders and recording withholding events.

Supported order types (domain enum):

- `CHILD_SUPPORT`
- `FEDERAL_TAX_LEVY`
- `STATE_TAX_LEVY`
- `STUDENT_LOAN`
- `CREDITOR_GARNISHMENT`
- `BANKRUPTCY`
- `OTHER`

Federal baselines modeled today (repository-derived):

- **Support (child/spousal) cap:** the payroll domain models the federal Consumer Credit Protection Act (CCPA, 15 U.S.C. § 1673(b)) cap as:
  - 50% when the obligor supports another spouse or child.
  - 60% when the obligor does not support another spouse or child.
  - +5 percentage points (to 55% / 65%) when arrears are at least 12 weeks.
- **Disposable earnings definition (for formulas):** by default, the domain computes disposable earnings as:
  - `baseDisposable = gross - mandatoryPreTaxDeductions`
  - `netForProtectedFloor = gross - mandatoryPreTaxDeductions - employeeTaxes`

  - Exception: for `STUDENT_LOAN`, the formula base also subtracts employee taxes (so the 15% ceiling applies to `gross - preTax - employeeTaxes`).

State overlays implemented today:

- **Michigan (MI):** modeled as an aggregate 50% support cap overlay in addition to the federal CCPA cap.
  - Effective cap for MI employees is `min(CCPA cap, 50% of disposable earnings)`.
- **CA / NV / NY:** currently modeled using the federal CCPA baseline parameters (no additional state aggregate cap overlay).

Priority and allocation algorithm (high level):

- **Ordering:** orders are processed in increasing `(priorityClass, sequenceWithinClass, orderId)`.
- **Requested amount:** each order computes a requested amount from a simple formula:
  - `PERCENT_OF_DISPOSABLE`
  - `FIXED_AMOUNT_PER_PERIOD`
  - `LESSER_OF_PERCENT_OR_AMOUNT`
  - `LEVY_WITH_BANDS` (statutory exemption bands)
- **Caps:** the requested amount is constrained by (when present):
  - Per-period cap (`DeductionPlan.perPeriodCap`) if a matching plan exists.
  - Annual cap (`DeductionPlan.annualCap`) using prior YTD.
  - Per-order `lifetimeCap` using prior YTD.
- **Aggregate support cap:** if `SupportCapContext` is provided and there are multiple `CHILD_SUPPORT` orders, the calculator:
  - Computes each support order's requested amount.
  - Computes an aggregate cap (`computeSupportCap`) from disposable earnings.
  - If the cap binds, scales support orders proportionally, assigning any rounding remainder to the last support order.
- **Disposable ceiling:** across *all* orders, withholding cannot exceed remaining disposable earnings.
- **Protected earnings floor:** if an order has a `ProtectedEarningsRule`, it is enforced as a net-pay floor and may further reduce the order's applied amount.
- **Arrears bookkeeping (per order):** if `arrearsBefore` is present, the calculator treats withholding as paying down arrears first (up to the arrears balance) and exposes current vs arrears splits in trace.

Trace visibility (key steps): When `includeTrace=true`, the calculation emits typed trace steps including:

- `DisposableIncomeComputed`
- `SupportCapApplied`
- `ProtectedEarningsApplied`
- `GarnishmentApplied` (includes requested/applied/disposable-before/after and arrears splits)
- `DeductionApplied`

HR API and ledger model (high level):

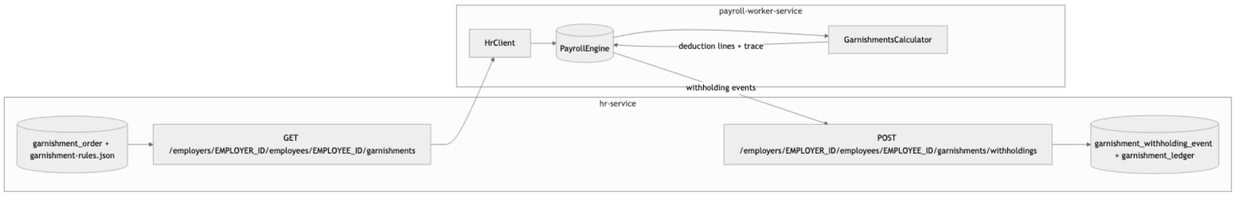
- **Orders (worker contract):** HR exposes a read endpoint that returns `GarnishmentOrderDto` objects as-of a date.
  - `GET /employers/{employerId}/employees/{employeeId}/garnishments?asOf=YYYY-MM-DD`
  - Orders are primarily sourced from the `garnishment_order` table and enriched with statutory rule config (`garnishment-rules.json`) to obtain the final `formula` and optional `protectedEarningsRule`.
- **Withholding events (worker → HR):** worker records what was withheld per order per paycheck.
  - `POST /employers/{employerId}/employees/{employeeId}/garnishments/withholdings`
  - HR persists event history (`garnishment_withholding_event`) and maintains an aggregate ledger (`garnishment_ledger`), using a unique constraint on `(employer_id, employee_id, order_id, paycheck_id)` to prevent double counting.
  - HR runs reconciliation to update `garnishment_order.current_arrears_cents` and can auto-mark orders `COMPLETED` when remaining arrears reaches 0.

- **Ops visibility:** HR exposes a read-only ledger view for debugging.
  - `GET /employers/{employerId}/employees/{employeeId}/garnishments/ledger`

Known limitations / not-yet-implemented (as of 2025-12-16):

- The domain treats garnishment behavior as **data-driven** (orders + formulas + protected floors). It does not yet implement a full statutory rules engine for every garnishment type; correctness depends on curated formulas and protected floors (via HR rule config and per-order overrides).
- Only support (`CHILD_SUPPORT`) has an explicit aggregate cap subsystem; other order types do not yet have a comparable "federal baseline + state overlay" parameterization beyond what is expressed via formula/protected floor.

Diagram: orders → calculation → withholding ledger


payroll-worker-service
HrClient
PayrollEngine
deduction lines + trace
GarnishmentsCalculator
withholding events
hr-service
garnishment_order + garnishment-rules.json
GET /employers/EMPLOYER_ID/employees/EMPLOYEE_ID/garnishments
POST /employers/EMPLOYER_ID/employees/EMPLOYEE_ID/garnishments/withholdings
garnishment_withholding_event + garnishment_ledger

1.5.3 5.1.2 Tax basis computation subsystem

Tax calculation in this repository is driven by an explicit `Map<TaxBasis, Money>` computed inside the payroll domain. This makes "what wages are taxable?" a first-class, traceable artifact of the paycheck computation.

Supported bases (domain enum):

- `Gross`
- `FederalTaxable`
- `StateTaxable`
- `SocialSecurityWages`
- `MedicareWages`
- `SupplementalWages`
- `FutaWages`

What goes into `Gross` vs cash gross:

- The domain computes **tax bases from the full earnings list**, including imputed earnings.
- Separately, the paycheck's **cash gross** (used for net pay) excludes imputed earnings.
  - Net cash is then computed from cash gross minus employee taxes and all deductions.

Basis formulas (repository-derived; current behavior):

- `Gross` = sum of **all** earning lines for the pay period.
- `SupplementalWages` = sum of earnings categorized as `SUPPLEMENTAL` or `BONUS`.
- `FederalTaxable` = `Gross - Σ(deductions with effect REDUCES_FEDERAL_TAXABLE)`.
- `StateTaxable` = `Gross - Σ(deductions with effect REDUCES_STATE_TAXABLE)`.
- `SocialSecurityWages` = `Gross - Σ(deductions with effect REDUCES_SOCIAL_SECURITY_WAGES)`.
- `MedicareWages` = `Gross - Σ(deductions with effect REDUCES_MEDICARE_WAGES)`.
- `FutaWages` = currently equal to `Gross` (placeholder for future FUTA-specific reduction semantics).

How deduction effects drive the bases:

- The basis builder consumes the engine's computed deduction lines plus the employer's `DeductionPlan` metadata.
- Each deduction plan has a `DeductionKind` plus an optional explicit `employeeEffects` set.
  - If `employeeEffects` is empty, the engine uses defaults by kind.
  - Examples of default behavior:
    - `PRETAX_RETIREMENT_EMPLOYEE` reduces federal + state taxable.

    * `HSA` reduces federal + state + Social Security wages + Medicare wages.
    * Most post-tax kinds (including garnishments) have `NO_TAX_EFFECT`.
- Fallback behavior for missing plans: if a deduction is treated as *pre-tax* in the engine pipeline but no plan is present in `plansByCode`, the basis builder reduces `FederalTaxable` (to preserve older tests / minimal configs).

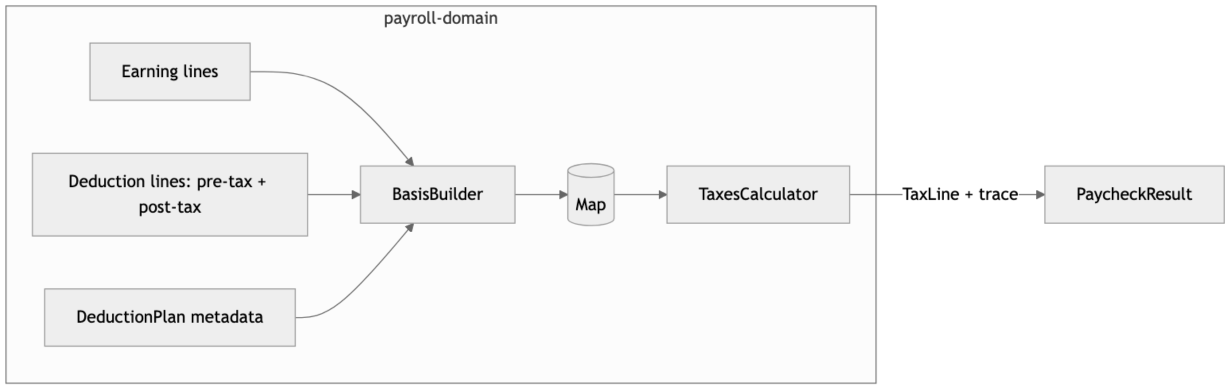
Trace visibility:

- When trace is enabled, taxes computation emits a `BasisComputed` step per basis:
  - `basis = <TaxBasis>`
  - `components = { gross, less*Deductions, supplemental, holiday, imputed, ... }` (stable keys)
  - `result = <Money>`

Known limitations / not-yet-implemented (as of 2025-12-16):

- Basis computation does not (yet) apply wage base caps (e.g., Social Security cap) at the basis layer. Wage caps are handled at **tax rule application time** (e.g. `TaxRule.FlatRateTax.annualWageCap`).
- `FutaWages` does not yet reflect FUTA-specific pre-tax reductions; it currently mirrors `Gross`.
- Basis "components" are geared toward explainability (gross vs less deductions, supplemental/holiday/imputed rollups) rather than a full earnings-by-code decomposition.

Diagram: earnings + deductions → basis map → tax rules



1.5.4 5.1.3 Tax rule application (basis consumption, locality allocation, caps)

Once bases are computed, the payroll domain applies tax rules from `TaxContext` to produce `TaxLine` outputs and `TaxApplied` trace steps.

Supported tax rule shapes (domain):

- `FlatRateTax` – `rate * taxableBasis`, with optional annual wage cap.
- `BracketedIncomeTax` – marginal brackets applied to the basis amount (with optional standard deduction and per-rule additional withholding).
- `WageBracketTax` – table lookup by basis amount, producing a fixed tax amount.

TaxContext sources and output buckets:

- Employee-side taxes are computed from:
  - `taxContext.federal + taxContext.state + taxContext.local`
- Employer-side taxes are computed from:
  - `taxContext.employerSpecific`

Locality allocation for local taxes:

- Local tax rules can carry an optional `localityFilter` string (e.g. `DETROIT`, `NYC`).

- For LOCAL-jurisdiction rules, the calculator allocates the basis across the set of selected localities:
  - Determine the set of distinct locality keys from local rules.
  - Resolve allocations from `TimeSlice.localityAllocations`:
    - If empty and there is one locality → 100% to that locality.
    - If empty and multiple localities → even split.
    - If provided → filter to known locality keys and normalize down only if the provided fractions sum to > 1.
  - Allocate cents using a "largest remainder" approach:
    - Take floor of `basis * fraction` for each locality.
    - Distribute remaining cents by descending fractional remainder (stable tiebreaker by locality key).
  - For a given local tax rule, use the allocated cents for the rule's `localityFilter` key.

Additional withholding (employee-elected extra per paycheck):

- `EmployeeSnapshot.additionalWithholdingPerPeriod` is modeled as a generic extra amount that is applied **once**.
- In `TaxesCalculator`, this extra amount is applied to the **first** "federal income tax" rule encountered, defined as:
  - `jurisdiction.type == FEDERAL` and `basis in {Gross, FederalTaxable}`.
- The extra amount is surfaced in trace via `AdditionalWithholdingApplied`.

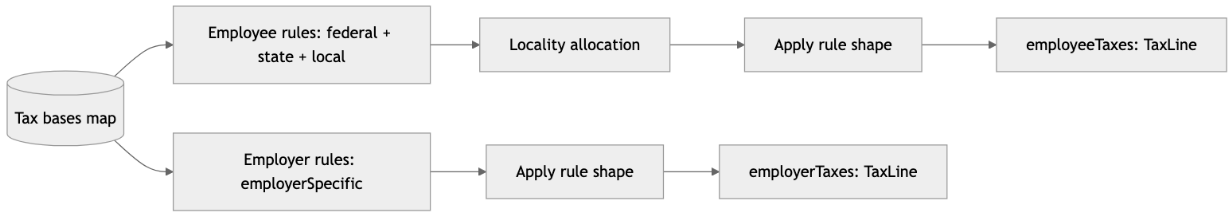
Wage base caps and special cases:

- Annual wage caps are enforced at *rule application time* for `FlatRateTax` via `annualWageCap` and prior YTD wages by basis.
  - Example use: Social Security wage base capping.
- FICA/Medicare skipping logic (rule suppression) is applied when the rule basis is `SocialSecurityWages` or `MedicareWages` and:
  - `EmployeeSnapshot.ficaExempt == true`, or
  - `EmployeeSnapshot.employmentType` is `HOUSEHOLD` or `ELECTION_WORKER` and the employee is still below the special YTD threshold.
- Additional Medicare (0.9%) is modeled as a special-case bracketed rule ID and applied only to the portion of wages above the IRS annual threshold, based on prior YTD Medicare wages.

Trace visibility (key steps):

- Per basis: `BasisComputed`
- Per applied tax: `TaxApplied` (includes brackets for bracketed income taxes)
- When employee-elected extra withholding is applied: `AdditionalWithholdingApplied`

Diagram: bases → employee rules + employer rules



1.5.5 5.1.4 Federal income tax withholding (Pub. 15-T engine)

In addition to the generic "apply rules to bases" tax engine, this repository contains a dedicated subsystem for **federal income tax withholding (FIT)** that models key IRS Pub. 15-T behaviors (W-4 Step 2/3/4 inputs and nonresident alien adjustments) in a more explicit, testable way.

High-level structure:

- `payroll-domain` contains the pure, framework-free computation layer under `payroll.engine.pub15t.*`:
  - `WithholdingProfile` – normalized W-4 view (modern vs legacy)
  - `WithholdingProfiles` + `LegacyW4Bridge` – derive a `WithholdingProfile` from `EmployeeSnapshot`
  - `NraAdjustment` – per-frequency “extra wages” adjustments for nonresident aliens (NRA)
  - `FederalWithholdingEngine` – computes per-paycheck FIT using either percentage or wage-bracket method
- `tax-api` exposes an adapter-style service interface:
  - `FederalWithholdingCalculator` / `DefaultFederalWithholdingCalculator`
  - This adapter uses `EarningsCalculator` + `BasisBuilder` + `FederalWithholdingEngine`.

Normalized W-4 inputs (`WithholdingProfile`): The Pub. 15-T engine operates on a `WithholdingProfile` derived from `EmployeeSnapshot`, including:

- `filingStatus`
- `step2MultipleJobs` (W-4 Step 2 checkbox)
- `step3AnnualCredit` (W-4 Step 3)
- `step4OtherIncomeAnnual` (W-4 Step 4a)
- `step4DeductionsAnnual` (W-4 Step 4b)
- `extraWithholdingPerPeriod` (W-4 Step 4c)
- `federalWithholdingExempt`
- `isNonresidentAlien` and `firstPaidBefore2020` (used for Pub. 15-T NRA tables)

Legacy (pre-2020) W-4 bridge behavior (current state):

- When the employee is treated as legacy (`W4Version.LEGACY_PRE_2020` or legacy fields are present), `LegacyW4Bridge` constructs a `WithholdingProfile` using a simplified Pub. 15-T “computational bridge” approach:
  - Derives synthetic Step 4(a) “other income” and Step 4(b) “deductions” values.
  - Uses an allowance constant (`$4,300` expressed in cents) to compute Step 4(b) from `legacyAllowances`.
  - Routes `legacyAdditionalWithholdingPerPeriod` into `extraWithholdingPerPeriod`.

Nonresident alien (NRA) adjustment:

- When `profile.isNonresidentAlien == true`, the engine adds a fixed “extra wages” amount (per pay frequency) to the *per-period* `FederalTaxable` basis **before** applying FIT.
- The adjustment uses one of two tables:
  - Table 1: pre-2020 W-4 and first paid before 2020
  - Table 2: 2020+ W-4 or first paid 2020 or later
- Note: the current `NraAdjustment` table values are explicitly marked as placeholders and are intended to be replaced with official year-specific values.

Withholding methods supported by the engine:

- **Percentage method** (`WithholdingMethod.PERCENTAGE`)
  - Selects a `TaxRule.BracketedIncomeTax` FIT rule based on:
    - `filingStatus`
    - `step2MultipleJobs` (prefers rule IDs containing `STEP2` when Step 2 is checked)
  - Annualizes the (possibly NRA-adjusted) per-period `FederalTaxable` wages using `periodsPerYear`.
  - Applies Step 4(a) / 4(b): `adjustedAnnualWages = annualWages + otherIncome - deductions`.
  - Computes annual tax by delegating to `TaxesCalculator` on a synthetic “annual period” input.
  - Applies Step 3 credits: `netAnnualTax = max(annualTax - step3Credits, 0)`.
  - De-annualizes: `perPeriodTax = netAnnualTax / periodsPerYear`.
  - Adds Step 4(c) extra withholding per period.
- **Wage-bracket method** (`WithholdingMethod.WAGE_BRACKET`)
  - Selects a `TaxRule.WageBracketTax` FIT rule using the same filing-status + Step 2 selection strategy.

  - Applies the wage-bracket table directly to per-period (possibly NRA-adjusted) `FederalTaxable` wages.
  - Adds Step 4(c) extra withholding per period.

Trace visibility:

- The Pub. 15-T engine emits trace as a sequence of `TraceStep.Note` messages documenting:
  - NRA extra wages applied
  - annualization inputs and adjusted annual wages
  - Step 3 credits and de-annualized per-period amounts

Known limitations / not-yet-implemented (as of 2025-12-16):

- The Pub. 15-T engine currently emits trace as `Note` messages (not as a fully typed trace structure specific to FIT).
- The legacy W-4 computational bridge is intentionally simplified and should be reviewed/extended for full parity with Pub. 15-T (it is designed to preserve inputs traceably while the bridge logic evolves).
- NRA adjustment amounts are flagged as placeholders pending authoritative year-specific table values.

1.5.6 5.1.5 Pub. 15-T wage-bracket tax content pipeline (CSV → JSON → DB)

While the Pub. 15-T withholding engine describes how federal FIT *should* be computed, the actual tables/rules are treated as **auditable, Git-managed artifacts** that can be updated yearly without changing runtime code.

Artifacts (repository-derived):

- Canonical curated CSV input (example year):
  - `tax-content/src/main/resources/wage-bracket-2025-biweekly.csv`
  - CSV schema: `frequency,filingStatus,variant,minCents,maxCents,taxCents`
- Deterministically generated JSON output:
  - `tax-content/src/main/resources/tax-config/federal-2025-pub15t-wage-bracket-biweekly.json`
- Metadata sidecars exist for curated inputs and are validated in CI (for supply-chain/audit hygiene):
  - `tax-content/src/main/resources/**/*.metadata.json`

Generation and validation (Gradle tasks):

- Generate wage-bracket JSON from curated CSV (year-parametric):
  - `./gradlew :tax-service:generateFederalPub15TWageBracketBiweekly -PtaxYear=2025`
  - Back-compat alias:
    - `./gradlew :tax-service:generateFederal2025BiweeklyWageBrackets`
- Validate tax config JSON structure:
  - `./gradlew :tax-service:validateTaxConfig`
- Validate curated CSV metadata:
  - `./gradlew :tax-service:validateTaxContentMetadata`
- Validate that generated JSON matches what would be produced from curated CSV:
  - `./gradlew :tax-service:validateGeneratedTaxArtifacts -PtaxYear=2025`

Import into runtime catalog (DB):

- JSON `TaxRuleFile` documents are imported into the `tax_rule` table via a framework-agnostic importer:
  - `tax-impl/src/main/kotlin/com/example/uspayroll/tax/persistence/TaxRuleConfigImporter.kt`
- Tax-service exposes the effective rules as a runtime `TaxContext` via:
  - `DbTaxCatalog` → `CachingTaxCatalog` → `CatalogBackedTaxContextProvider`

How the generated tables are consumed:

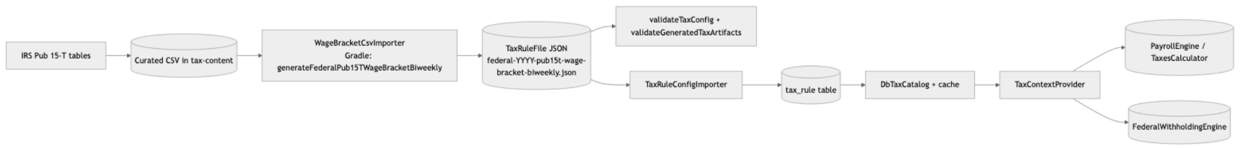
- `TaxesCalculator` can apply wage-bracket rules generically (it supports `TaxRule.WageBracketTax`).

- `FederalWithholdingEngine` (Pub. 15-T) selects a FIT rule by filing status (and Step 2 variant) and can use:
  - Percentage method rules (`TaxRule.BracketedIncomeTax`), or
  - Wage-bracket method rules (`TaxRule.WageBracketTax`) generated from the curated CSV.

Optional / ancillary tooling:

- The repo also includes an offline generator (`Pub15TWageBracketGenerator`) that derives a `WAGE_BRACKET` config by running the core tax engine over a wages grid against a canonical BRACKETED config. This is primarily used by tests/tools; the primary production-oriented pipeline is CSV → JSON.

Diagram: Pub. 15-T content flow (authoritative source → runtime behavior)



1.5.7 5.2 HR service (employee + pay period facts)

Capabilities:

- Exposes as-of employee snapshots and pay periods via HTTP routes.
- Contains endpoints for pay period lookup by check date.
- Includes garnishment endpoints used by worker-service for withholding events.

Primary location:

- `hr-service` (`/employers/{employerId}/employees/{employeeId}/snapshot`, `/pay-periods/...`)

1.5.8 5.3 Tax service (rules catalog → TaxContext)

Capabilities:

- Loads tax rules from a DB-backed catalog and returns an effective `TaxContext`.
- Supports optional employee-context filters (resident state, work state, localities) for rule selection.
- Supports employer-specific overlays layered on top of generic statutory rules.

Primary location:

- `tax-service` (`GET /employers/{employerId}/tax-context?asOf=...&residentState=...&workState=...&locali`
- `tax-content` for curated inputs and generated JSON rule files.

1.5.9 5.4 Labor service (labor standards context)

Capabilities:

- Loads labor standards and returns a per-employer effective labor standards context.
- Supports locality codes (where present) and default baseline behavior.
- Includes a non-engineering-friendly CSV workflow and deterministic regeneration of JSON + SQL.

Primary location:

- `labor-service` (`GET /employers/{employerId}/labor-standards?asOf=...&state=...&homeState=...&locality`

1.5.10 5.5 Payrun orchestration (queue-driven finalize + corrections)

Capabilities:

- Starts payrun finalization with idempotency keys.

- Queue-driven execution model: one job per employee item.
- Supports corrections workflows:
  - void
  - reissue
  - retro adjustments (adjustment runs)
- Provides reconciliation endpoints for operators (internal-only), including:
  - requeue queued/stale-running/failed items
  - force finalize and enqueue events
  - rebuild payment projections

Primary location:

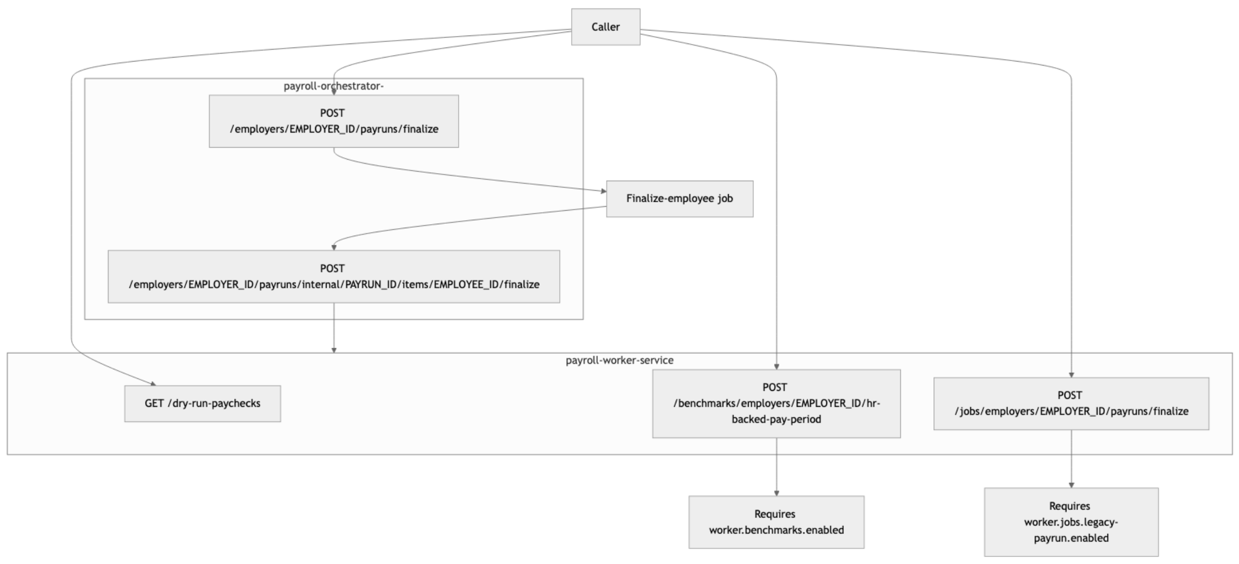
- `payroll-orchestrator-service`

1.5.11 5.6 Worker service (compute + job consumption)

Capabilities:

- Computes paychecks by composing HR, Tax, and Labor contexts.
- Consumes per-employee finalization jobs (RabbitMQ) and performs paycheck computation as part of orchestrator-driven payruns.
- Exposes:
  - Demo endpoint (always available; intended for local experimentation):
    - `GET /dry-run-paychecks`
  - Optional, feature-flagged endpoints intended for testing/benchmarking:
    - Benchmark HR-backed computation:
      - `POST /benchmarks/employers/{employerId}/hr-backed-pay-period` (guarded by `worker.benchmarks.enabled` + shared token)
    - Legacy/dev-only finalize job API:
      - `POST /jobs/employers/{employerId}/payruns/finalize` (guarded by `worker.jobs.legacy-payrun.e`
- Emits operational metrics for garnishment behavior.
- Provides DLQ replay tooling for RabbitMQ employee-finalize jobs (guarded by internal auth and disabled by default).

Diagram: worker endpoints taxonomy (what is always on vs feature-flagged)


Caller
payroll-orchestrator-
POST /employers/EMPLOYER_ID/payruns/finalize
Finalize-employee job
POST /employers/EMPLOYER_ID/payruns/internal/PAYRUN_ID/items/EMPLOYEE_ID/finalize
payroll-worker-service
GET /dry-run-paychecks
POST /benchmarks/employers/EMPLOYER_ID/hr-backed-pay-period
POST /jobs/employers/EMPLOYER_ID/payruns/finalize
Requires worker.benchmarks.enabled
Requires worker.jobs.legacy-payrun.enabled

Primary location:

- `payroll-worker-service`

1.5.12 5.7 Payments service (system-of-record + provider seam)

Capabilities:

- Serves as system-of-record for payment batches and paycheck-level payment lifecycle.
- Integrates with payment rails via a strict provider port (`PaymentProvider`) that avoids raw bank PII.
- Supports reconciliation flows where orchestrator can rebuild projections from payments-service.

Primary location:

- `payments-service`

1.5.13 5.8 Reporting and filings

Capabilities:

- Defines stable ledger event contracts for downstream reporting/filings projections.
- Provides initial filing computations (941/940/W-2/W-3/state withholding summaries) as "shapes" based on ledger/projections.
- Provides validation hooks for readiness to compute filings.

Primary locations:

- `reporting-service`
- `filings-service` (`/employers/{employerId}/filings/...`)

1.5.14 5.9 Operational safety and governance

Capabilities:

- Deterministic idempotency strategies for external POST endpoints via `Idempotency-Key`.
- Outbox pattern for reliable publishing to Kafka and RabbitMQ.
- Inbox pattern for consumer-side de-duplication.
- Detailed runbooks for DLQ replay, reconciliation, yearly updates, and deployment hardening.

Primary locations:

- `docs/ops/idempotency-and-replay-invariants.md`
- `docs/ops/dlq-replay-reconciliation.md`
- `payroll-orchestrator-service` outbox relays
- `messaging-core` inbox utilities

1.6 6. Architecture

1.6.1 6.1 Repository structure and module inventory

This is a Gradle multi-module monorepo.

Core (functional core):

- `shared-kernel`
- `payroll-domain`

Service modules (implemented):

- `edge-service` (ingress gateway)
- `hr-api`, `hr-client`, `hr-service`
- `tax-api`, `tax-config`, `tax-catalog-ports`, `tax-impl`, `tax-content`, `tax-service`
- `labor-api`, `labor-service`
- `payroll-orchestrator-service`
- `payroll-worker-service`
- `payments-service`

- `reporting-service`
- `filings-service`

Shared infrastructure modules:

- `web-core` (web conventions, headers, problem details, redaction)
- `persistence-core` (DB building blocks)
- `messaging-core` (outbox/inbox, event types)
- `tenancy-core` (DB-per-employer routing)

Placeholder/empty modules currently included in settings but empty on disk:

- `identity-service`
- `integrations-service`
- `notification-service`
- `time-ingestion-service`
- `hr-domain`, `tax-domain`, `time-domain`

1.6.2 6.2 Runtime topology (multi-service)

Target runtime shape:

- `edge-service` is the only intended internet-exposed entrypoint.
- Internal services are deployed as private services, primarily reachable only from within the cluster/VPC.

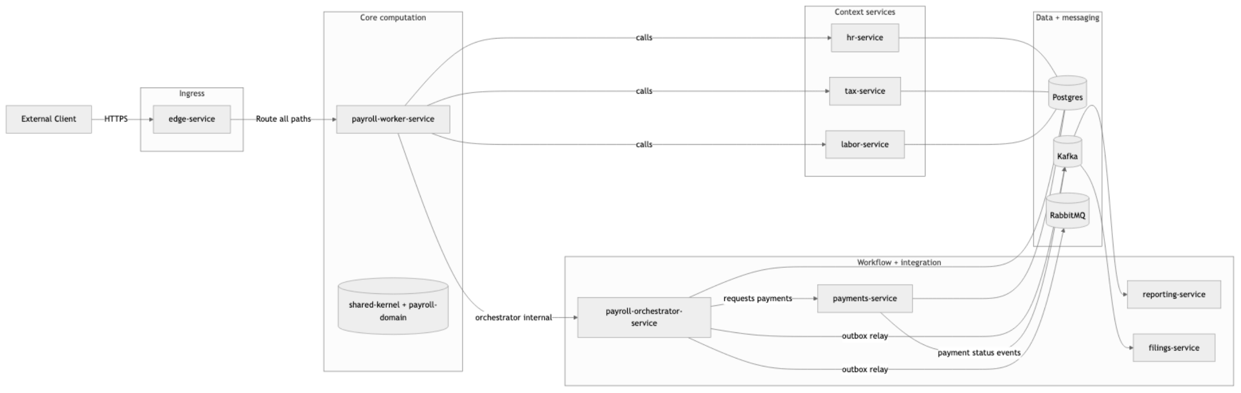
Gateway routing:

- Edge routes all paths to worker-service by default (`edge-service/src/main/resources/application.yml`).

Representative internal dependencies:

- worker-service calls HR, Tax, and Labor services.
- orchestrator coordinates payrun lifecycle and uses RabbitMQ for per-employee finalization jobs.
- orchestrator publishes durable events via outbox to Kafka (reporting/filings and integration streams).
- payments-service processes payment batches via a provider integration seam.

Diagram: runtime topology (high-level)



1.6.3 6.3 Data and tenancy model

Target tenant isolation:

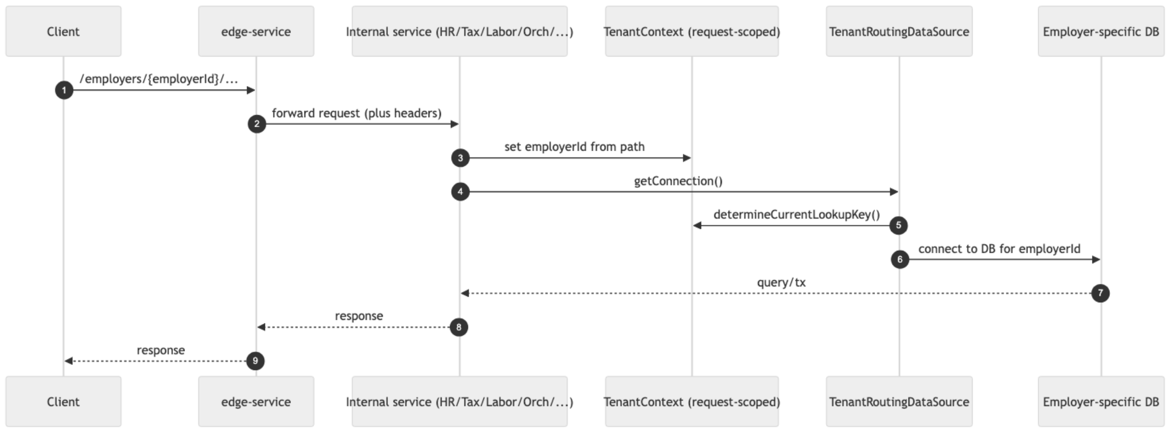
- Database-per-employer (DB-per-tenant), per bounded context.

Implementation approach:

- Services use a routing datasource (`TenantRoutingDataSource`) keyed by a request-scoped tenant context.

- Tenant resolution is path-based for routes under `/employers/{employerId}/...`.

Diagram: DB-per-employer request routing (conceptual)


Client
edge-service
Internal service (HR/Tax/Labor/Orch/...)
TenantContext (request-scoped)
TenantRoutingDataSource
Employer-specific DB
1 /employers/{employerId}/...
2 forward request (plus headers)
3 set employerId from path
4 getConnection()
5 determineCurrentLookupKey()
6 connect to DB for employerId
7 query/tx
8 response
9 response

Operational implications:

- Tenant provisioning, migration, backup/restore are first-class operational workflows and are documented with baseline scripts.

Primary reference:

- `docs/tenancy-db-per-employer.md`

1.6.4 6.4 Messaging, outbox, inbox

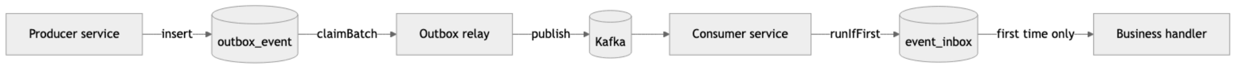
Outbox pattern:

- Producers persist events in `outbox_event` and relays publish them to Kafka or RabbitMQ.
- Relays claim batches under DB locks and use lease tokens to remain correct under concurrency and crashes.

Inbox pattern:

- Kafka consumers are expected to de-duplicate via an inbox table keyed by `(consumer, event_id)`.

Diagram: outbox + inbox (replay-safe messaging)



Primary references:

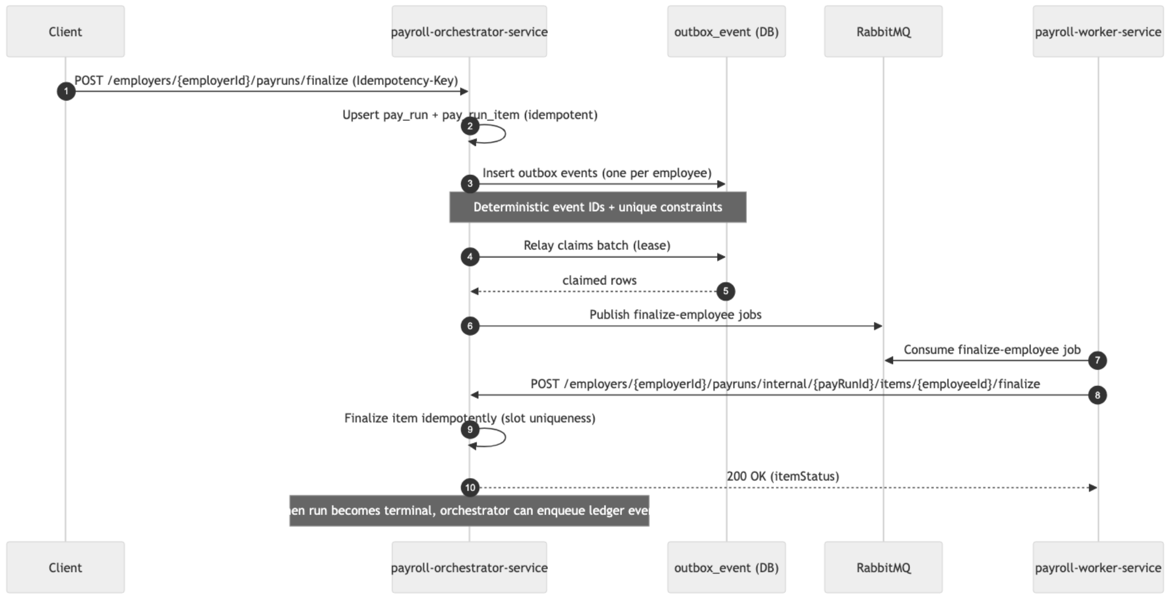
- `docs/ops/idempotency-and-replay-invariants.md`
- Outbox relay implementations in `payroll-orchestrator-service`.

1.6.5 6.5 Core workflows (high level)

1.6.5.1 Payrun finalize (queue-driven)

1) Client calls orchestrator: `POST /employers/{employerId}/payruns/finalize` with `Idempotency-Key`.
2) Orchestrator records payrun + per-employee items and enqueues one Rabbit job per employee via outbox.
3) Worker replicas consume jobs and call orchestrator internal endpoint:
    - `POST /employers/{employerId}/payruns/internal/{payRunId}/items/{employeeId}/finalize`
4) Orchestrator marks items succeeded/failed idempotently.
5) Orchestrator computes terminal status and, when approved, publishes durable ledger events.

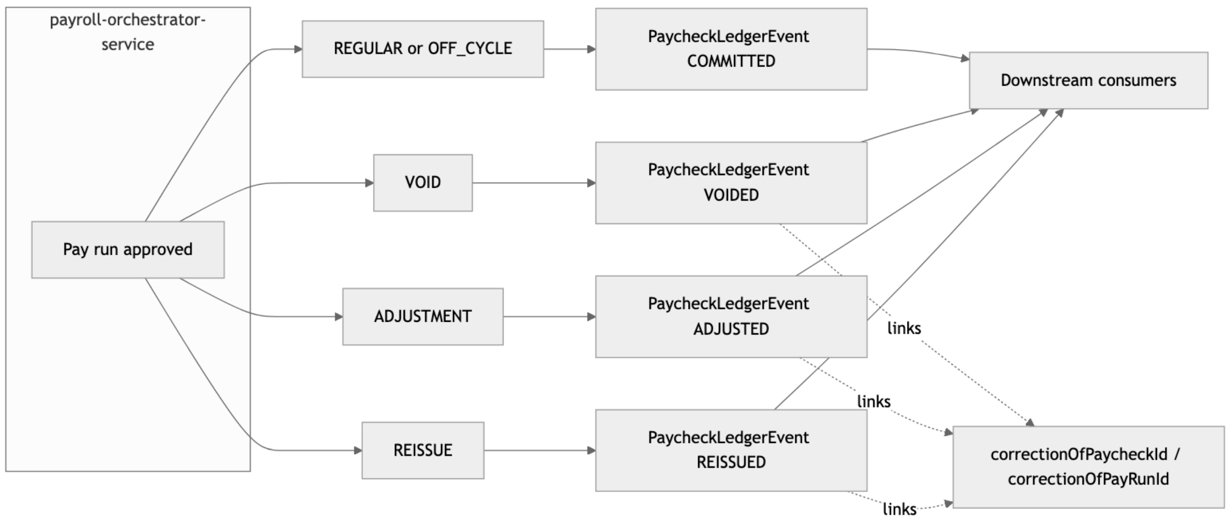
Diagram: payrun finalize (queue-driven happy path)


Client
payroll-orchestrator-service
outbox_event (DB)
RabbitMQ
payroll-worker-service
1 POST /employers/{employerId}/payruns/finalize (Idempotency-Key)
2 Upsert pay_run + pay_run_item (idempotent)
3 Insert outbox events (one per employee)
Deterministic event IDs + unique constraints
4 Relay claims batch (lease)
5 claimed rows
6 Publish finalize-employee jobs
7 Consume finalize-employee job
8 POST /employers/{employerId}/payruns/internal/{payRunId}/items/{employeeId}/finalize
9 Finalize item idempotently (slot uniqueness)
10 200 OK (itemStatus)
en run becomes terminal, orchestrator can enqueue ledger eve
Client
payroll-orchestrator-service
outbox_event (DB)
RabbitMQ
payroll-worker-service

1.6.5.2 Corrections and retro

- Corrections are expressed as new payruns with explicit types (VOID/REISSUE/ADJUSTMENT) and sequences.
- Ledger events encode action semantics for downstream consumers.

Diagram: corrections model → ledger actions (consumer contract)


payroll-orchestrator-service
Pay run approved
REGULAR or OFF_CYCLE
VOID
ADJUSTMENT
REISSUE
PaycheckLedgerEvent COMMITTED
PaycheckLedgerEvent VOIDED
PaycheckLedgerEvent ADJUSTED
PaycheckLedgerEvent REISSUED
Downstream consumers
correctionOfPaycheckId / correctionOfPayRunId
links
links
links

Primary reference:

- `docs/ops/reporting-filings-paycheck-ledger-events.md`

1.6.5.3 Payments initiation

- Orchestrator initiates payments with an idempotency key.
- Payments-service is system-of-record; orchestrator may maintain projections and can rebuild them.

1.7 7. Customization model

1.7.1 7.1 Employer-specific configuration

Tax overlays:

- Employer-specific tax overlays are modeled via `tax_rule.employer_id` and layered with generic rules.

Earnings and deductions:

- The domain consumes employer configuration via ports:
  - `EarningConfigRepository`
  - `DeductionConfigRepository`
- This allows a future config service (DB/UI) without changing the payroll engine.

Primary reference:

- `docs/employer-config.md`

1.7.2 7.2 Statutory content customization (policy/ops workflow)

Tax content:

- Canonical inputs in `tax-content/src/main/resources`.
- Deterministic generation into JSON `TaxRuleFile` documents under `tax-content/src/main/resources/tax-config`.
- Import into `tax_rule` via `TaxRuleConfigImporter`.

Labor standards:

- Canonical CSV under `labor-service/src/main/resources`.
- Deterministic generation into JSON + SQL via Gradle tasks or helper script.

Diagram: tax content pipeline (CSV → JSON → DB → runtime)

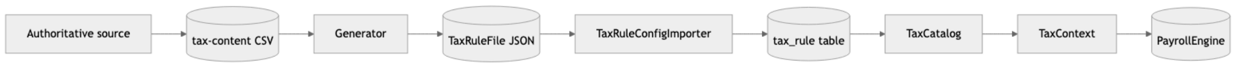
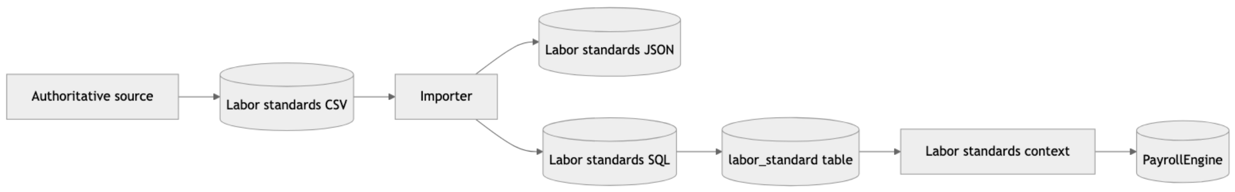


Diagram: labor standards pipeline (CSV → JSON + SQL)



Primary references:

- `docs/tax-content-operations.md`
- `tax-service/README.md`
- `labor-service/README.md`

1.7.3 7.3 Deployment-time configuration

Key patterns:

- Spring Boot property namespaces per service.
- Explicit feature gates (many internal endpoints disabled by default).
- Separate configs for internal auth and gateway auth.

Examples:

- Edge auth modes: DISABLED (guarded), HS256 (dev), OIDC (production target).

- Worker internal replay endpoints require `worker.internal-auth.shared-secret`.
- Orchestrator internal endpoints can use internal JWT keyrings or shared secret headers.

Primary reference:

- `docs/security-boundary.md`
- `docs/ops/secrets-and-configuration.md`

1.8 8. Extensibility model

1.8.1 8.1 Adding new payroll calculations

- Add new domain models under `com.example.uspayroll.payroll.model.*`.
- Add new orchestration/calculation logic under `com.example.uspayroll.payroll.engine.*`.
- Preserve purity: side effects remain at service boundaries.

1.8.2 8.2 Adding new tax rules/jurisdictions

- Extend curated content (CSV/JSON) and pipelines in `tax-content`.
- Extend selection and persistence layers in `tax-service/tax-impl`.
- Add golden tests for statutory interpretation and year transitions.

1.8.3 8.3 Adding new labor standards

- Extend the labor standards CSV schema (engineering-owned), then update importer/generator.
- Add locality rows and extend DB schema as needed.

1.8.4 8.4 Integrating payment rails

- Implement `PaymentProvider` in `payments-service`.
- Keep bank/account details tokenized and outside events and core DB tables.
- Add asynchronous status update mechanisms for real providers.

Primary reference:

- `docs/ops/payments-provider-integration-seam.md`

1.8.5 8.5 Adding downstream consumers

- Prefer consuming stable ledger events (Kafka) rather than orchestrator internal tables.
- Use inbox de-duplication for replay safety.

Primary reference:

- `docs/ops/reporting-filings-paycheck-ledger-events.md`

1.9 9. Non-functional requirements and quality attributes

1.9.1 9.1 Correctness and determinism

- Payroll engine designed to be deterministic for a given set of inputs.
- Tax and labor pipelines are designed to be traceable from authoritative sources → curated CSV → generated JSON/SQL → DB → runtime behavior.

1.9.2 9.2 Reliability: idempotency and replay safety

Design commitments:

- Stable event IDs.
- Inbox de-duplication for Kafka consumers.

- Outbox claim/lease semantics safe under concurrency and crashes.
- Idempotency keys for client-facing "create work" POST endpoints.

Primary reference:

- `docs/ops/idempotency-and-replay-invariants.md`

1.9.3 9.3 Observability

- Structured logging conventions with correlation IDs.
- Metrics for key workflows (payrun finalization, garnishments, queue depth).
- SLO guidance with example PromQL queries and alert rules.
- Distributed tracing via OTLP exporter configuration.

Primary references:

- `docs/runtime-architecture.md`
- `docs/ops/slo-core-workflows.md`
- `docs/ops/payrun-jobs-observability.md`

1.9.4 9.4 Security

Boundary model:

- Ingress authn/authz at edge-service.
- Internal endpoints protected (shared secret or internal JWT), with a roadmap to mTLS.
- Reduced blast radius via DB-per-employer and least-privilege credentials.

Supply-chain posture:

- Dependency locking and verification metadata.
- Vulnerability scanning and SBOM generation.
- Code scanning (SAST) and DAST baseline.

Primary references:

- `docs/security-boundary.md`
- `docs/security-threat-model.md`
- `.github/workflows/security-scan.yml`
- `.github/workflows/dast.yml`

1.9.5 9.5 Compliance, PII, and retention

Baseline expectations:

- Avoid PII in logs (prefer stable IDs).
- Encrypt at rest/in transit via platform controls.
- Document retention/export/delete workflows.

Primary references:

- `docs/pii-and-retention.md`
- `docs/ops/retention-export-delete.md`

1.9.6 9.6 Enterprise-grade framework assessment (repository-derived)

This repository is best described as an **enterprise-grade payroll platform framework**: it contains many of the *engineering and operational primitives* you need for a tier-1 payroll system (determinism, replay-safety, content governance, security posture scaffolding) and it also now includes a meaningful set of enterprise workflow capabilities that are marked **Done** in the enterprise-readiness capability register (see Section 11.1).

What makes it "enterprise-grade" (as a framework)

- **Functional core / deterministic domain**: core calculations are isolated in `payroll-domain` and designed to be pure and testable.
- **Operational safety by default**:
  - HTTP idempotency conventions (`Idempotency-Key`) and DB uniqueness constraints for irreversible effects.
  - Outbox relays (Kafka + Rabbit) with correct claim/lease semantics.
  - Inbox de-duplication pattern for Kafka consumers.
  - DLQ replay and reconciliation runbooks + internal endpoints.
- **Content governance and traceability**: tax and labor policy data is treated as **versioned artifacts** (CSV/JSON/SQL) with deterministic generators and validation hooks.
- **Security boundary clarity**:
  - Edge/gateway is the intended ingress enforcement point.
  - Internal privileged endpoints are explicitly separated and guarded (shared secret / internal JWT scaffolding).
- **Production deployment posture**: Kubernetes baseline (probes, non-root, read-only FS, network policy stance) and supply-chain tooling (locking/verification, SBOMs, vuln scanning).

Important qualification

- "Enterprise-grade framework" here does **not** mean "fully enterprise complete":
  - coverage breadth (all state/local edge cases) and multi-year backtesting are not fully complete,
  - identity service is currently a placeholder,
  - tenancy automation and production authn/authz wiring are still evolving per the repository's enterprise-readiness capability register.

Codebase summary (what you're actually getting)

- Language/runtime: Kotlin/JVM (Java 21), Spring Boot services, Gradle multi-module build.
- Architecture style: functional-core + ports/adapters; service boundaries for HR/Tax/Labor/Worker/Orchestrator/Paym
- Operational primitives: outbox/inbox, idempotency keys, deterministic event IDs, replay tooling, runbooks.
- Delivery artifacts: Dockerfiles, Docker Compose stack, Kustomize overlays for dev/prod.

Code quality (signals present in the repository)

- Build hygiene and consistency:
  - `ktlint` + `detekt` wired across Kotlin subprojects.
  - JaCoCo coverage enforcement with per-module minimums.
  - Consistent "ports + adapters" wiring with domain purity preserved in `payroll-domain`.
- Test posture (representative):
  - Workflow/integration tests exist for key enterprise workflows (e.g., off-cycle, void/reissue, retro adjustments, reconciliation/projection rebuild, ledger events, filings shapes).
  - Golden/structural validators exist for curated tax/labor artifacts and metadata sidecars.
- Supply-chain posture:
  - Gradle dependency locking + verification metadata.
  - CI workflows for dependency scanning, SBOM generation/validation, and secret scanning.
- Ops/readiness documentation density:
  - runbooks for DR/restore, replay/reconciliation, yearly content updates, and production hardening.
  - Clear contributor hygiene guidance (e.g., generated `**/build/**` artifacts should not be treated as source docs).

Architecture quality (signals present in the repository)

- Clear separation between:
  - calculation domain (`payroll-domain`) vs
  - statutory catalogs/pipelines (tax/labor) vs
  - orchestration/workflows (orchestrator/worker) vs

    - ingress policy (edge).
- Strong bias toward **idempotent, replay-safe workflows**, which is a key differentiator for enterprise systems.
- Explicit "target state" documents (security boundary, tenancy model, SLOs) that reduce ambiguity for teams scaling the system.

Estimated replacement value (if rebuilt from scratch) This is necessarily a **range estimate** because replacement cost depends on desired coverage breadth (all 50 states + locals), compliance posture (SOC2/ISO evidence, audits), and how much of the existing operational posture you want to match.

Assumptions for the estimate below

- Goal is "feature parity with this repository as it exists", including:
    - enterprise HR system-of-record primitives (writes + bitemporal/effective dating + audit + idempotency)
    - tax/labor content pipelines + governance
    - orchestrator-driven payrun workflows (off-cycle, void/reissue, retro adjustments) and operational controls
    - payments service seam + reconciliation/projection rebuild helpers
    - reporting/filings event contracts and initial filings "shape" endpoints
    - outbox/inbox primitives + runbooks
    - edge auth scaffolding + deployment baselines
- A senior team familiar with Kotlin/Spring and distributed systems.
- Does not include external costs for legal/compliance audits or acquiring proprietary tax data.

Rough effort breakdown (engineering time)

- Functional payroll domain + explainability + core tests: ~4–8 engineer-months
- HR system-of-record (writes, effective dating/bitemporal, audit log, idempotency, pay schedules/period generation): ~4–8 engineer-months
- Tax catalog + CSV→JSON tooling + importer + validators + tests: ~4–8 engineer-months
- Labor standards tooling + importer + validators + tests: ~2–4 engineer-months
- Orchestrator + worker integration (queue-driven finalize, corrections, retro, reconciliation tools, workflow tests): ~7–14 engineer-months
- Payments service seam + reconciliation/projection rebuild support + tests: ~2–5 engineer-months
- Reporting/filings event contracts + initial filings "shapes" + tests: ~2–5 engineer-months
- Messaging core (outbox/inbox) + relays + retry semantics: ~3–6 engineer-months
- Edge gateway authn/authz scaffolding + header propagation: ~2–4 engineer-months
- Deployment baselines (Docker/K8s) + CI security/supply-chain posture + docs/runbooks: ~4–8 engineer-months

Total to reach comparable maturity: **~30–60 engineer-months** (roughly **2.5–5 engineer-years**).

Cost translation (very approximate)

- Using typical fully-loaded engineering costs (salary + benefits + overhead), this often lands in the ballpark of 1.0M–**4.0M USD** to rebuild to comparable maturity.

This replacement estimate can be tailored to a specific target (e.g., "first production deployment for 3 states", "nationwide withholding", "SOC2-ready posture") based on intended coverage and compliance goals.

1.10 10. Deployment and operations

1.10.1 10.1 Local development (Docker Compose)

- `docker-compose.yml` defines a local multi-service stack with Postgres and service containers.
- Edge is the primary exposed entrypoint.

1.10.2 10.2 Kubernetes (Kustomize)

- Baseline manifests under `deploy/k8s/base`.
- Overlays for `dev` and `prod` environments.
- Hardened defaults: non-root, read-only root filesystem, probes, network policies (prod overlay).

Primary references:

- `deploy/k8s/README.md`
- `docs/ops/production-deployment-hardening.md`

1.11 11. Known limitations and roadmap signals

As of 2025-12-16, the repository explicitly calls out:

- Year coverage primarily for 2025 tax and labor rules.
- Coverage breadth is not yet complete nationwide.
- Production-grade authn/authz and tenancy automation remain in progress.
- Some enterprise readiness work is still **Partial**, especially:
  - multi-jurisdiction employment scenarios (C3)
  - end-to-end "golden test" coverage audit (X0)

For the current enterprise-readiness capability register (Done/Partial/Not Started), see:

- `docs/ops/enterprise-readiness-capability-backlog.md` (capability register)

1.11.1 11.1 Enterprise-readiness capability snapshot (as of 2025-12-16)

Done:

- A0 HR write API + persistence for employee profile
- A1 Effective-dated employee attributes (beyond compensation)
- A2 Pay period management as a first-class workflow
- A3 Bitemporal HR (valid time + system time) OR explicitly-defined audit semantics
- B0 Content metadata + traceability standard
- B1 Formal approval workflow for content changes
- B2 Yearly update playbooks expanded to state tax + labor
- B3 Coverage expansion plan (state/local)
- C0 Off-cycle pay runs
- C1 Corrections: void / reissue
- C2 Retro pay driven by effective-dated HR changes
- D0 Payment reconciliation contract
- D1 Bank file / payment provider integration seam (sandbox provider)
- E0 Reporting/filings event contract
- E1 Quarterly/annual filing "shape" (initial shape APIs)

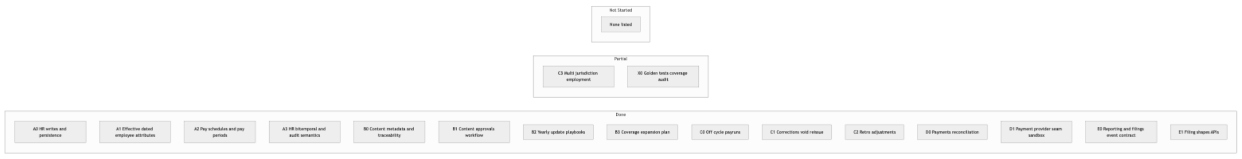
Partial:

- C3 Multi-jurisdiction employment scenarios
- X0 Golden tests coverage

Not Started:

- (none currently listed)

Diagram: enterprise-readiness status overview


Not Started
None listed
Partial
C3 Multi jurisdiction employment
X0 Golden tests coverage audit
Done
A0 HR writes and persistence
A1 Effective dated employee attributes
A2 Pay schedules and pay periods
A3 HR bitemporal and audit semantics
B0 Content metadata and traceability
B1 Content approvals workflow
B2 Yearly update playbooks
B3 Coverage expansion plan
C0 Off cycle payruns
C1 Corrections void reissue
C2 Retro adjustments
D0 Payments reconciliation
D1 Payment provider seam sandbox
E0 Reporting and filings event contract
E1 Filing shapes APIs

1.12 12. Appendix: key reference documents

Architecture:

- `docs/architecture.md`
- `docs/runtime-architecture.md`

Security:

- `docs/security-boundary.md`
- `docs/security-threat-model.md`
- `docs/security-privileged-ops.md`

Tax and labor content:

- `docs/tax-content-operations.md`
- `tax-service/README.md`
- `labor-service/README.md`

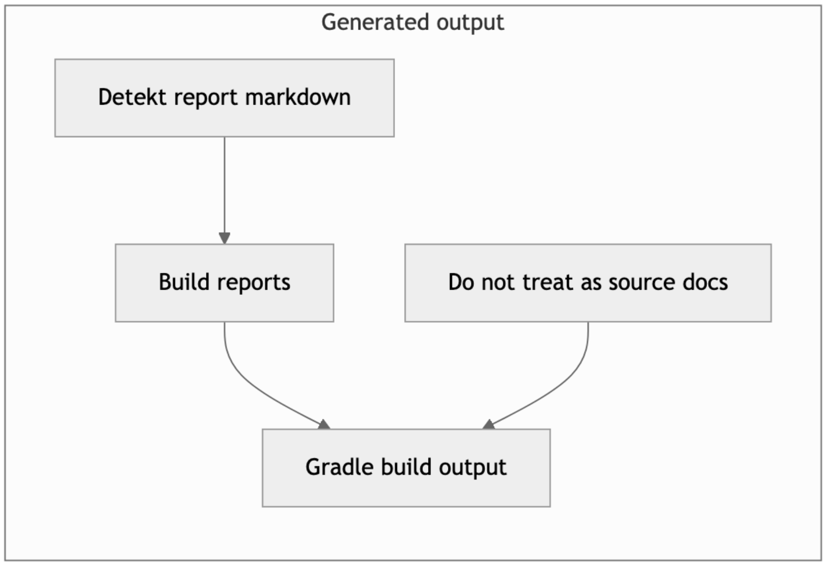
Ops:

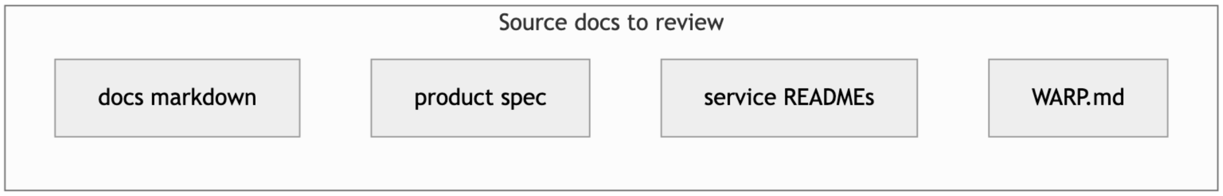
- `docs/ops/idempotency-and-replay-invariants.md`
- `docs/ops/dlq-replay-reconciliation.md`
- `docs/ops/production-deployment-hardening.md`
- `docs/ops/secrets-and-configuration.md`
- `docs/ops/slo-core-workflows.md`

Repo hygiene / contributor guidance:

- `WARP.md` (includes guidance that `**/build/**` artifacts such as Detekt reports should not be treated as source docs)

Diagram: documentation vs generated artifacts





1.13 13. Payroll system feature review (repository vs typical expectations)

This appendix evaluates this repository against what a production payroll system is typically expected to provide.

Note: This appendix is an embedded copy of `docs/payroll-system-feature-review.md`. Its internal section numbering restarts at 1.

Date: 2025-12-16 Scope: repository-derived review of `us-payroll-platform`

1.14 1. How to read this document

This is a practical "gap and strengths" review of the repository against what a production payroll system is typically expected to provide.

For each area, you'll see:

- What a payroll system is typically expected to support
- What this repository appears to implement today (based on code + docs)
- Notes / gaps / maturity signals

This is not a compliance certification and does not assert statutory completeness.

1.15 2. High-level: where this repository is strong

This repository is unusually strong (for its current maturity stage) in the engineering and ops primitives that are normally hard to retrofit later:

- Functional-core payroll computation (`payroll-domain`) separated from service concerns.

- Deterministic, replay-safe workflow semantics (Idempotency-Key, outbox/inbox, DLQ/reconciliation) – see `docs/ops/idempotency-and-replay-invariants.md` and `docs/ops/dlq-replay-reconciliation.md`.
- Content governance pipelines for tax and labor data (CSV → JSON → DB/SQL) with yearly-update playbooks.
- Multi-tenant isolation target of DB-per-employer with migration and ops scaffolding – see `docs/tenancy-db-per-employer.md`.
- Production posture scaffolding: hardened K8s baseline, supply-chain scanning, SBOM generation.

1.16 3. Feature-by-feature review

1.16.1 3.1 Employer / tenant model

Expected:

- Clear tenant boundary and isolation strategy
- Deterministic tenant routing in services
- Tenant-level export/retention/delete and DR readiness

In this repository:

- DB-per-employer tenant isolation is an explicit target (`docs/tenancy-db-per-employer.md`).
- Tenant routing is implemented via a routing datasource (`tenancy-core/src/main/kotlin/com/example/uspayroll/t`
- Retention/export/delete posture is documented with scaffolding (`docs/ops/retention-export-delete.md`).
- DR/restore playbook exists (`docs/ops/backup-restore-dr.md`).

Notes / gaps:

- DB-per-employer is operationally heavy; the repository calls out the need for automation (provisioning, secrets, migrations).

1.16.2 3.2 HR system-of-record (employee facts)

Expected:

- Employee profile + work/home jurisdiction (for tax/labor)
- Effective-dated history and audit trail
- Deterministic "as-of" reads (for recompute and audits)

In this repository:

- Employee snapshot model is rich and payroll-relevant (`payroll-domain/.../EmployeeTypes.kt`).
- HR service exposes snapshot reads via HTTP (`hr-service/.../HrRoutes.kt`).
- Bitemporal + audit semantics are explicitly designed and documented (`docs/ops/hr-bitemporal-and-audit-semanti`

Notes / gaps:

- The enterprise-readiness capability register now marks core HR write + effective dating + audit semantics as **Done** (A0–A3). Remaining work is primarily around breadth (additional HR attributes and validations), operator/admin workflows, and long-horizon backtesting.

1.16.3 3.3 Pay schedules and pay periods

Expected:

- Pay schedules (weekly/biweekly/semi-monthly/etc.)
- Pay period generation, validation, and stable identifiers
- Deterministic lookup by check date

In this repository:

- Pay frequencies are modeled (`payroll-domain/.../TimeTypes.kt`).
- HR service exposes pay period reads including by check date (`hr-service/.../HrRoutes.kt`).

- Pay-period validation rules and gap-free options are documented (`docs/ops/hr-pay-period-management.md`).

Notes / gaps:

- Pay schedule upsert + pay period generation/validation is present and marked **Done** (A2) in the enterprise-readiness capability register. Remaining work is typically around admin UX, more schedule variants, and operational controls.

1.16.4 3.4 Paycheck computation engine (functional core)

Expected:

- Deterministic paycheck calculation with explainability
- Support for common pay bases: salaried and hourly
- Handling of supplemental earnings
- Overtime and basic labor-rule hooks

In this repository:

- Salaried and hourly base compensation are first-class (`BaseCompensation` in `payroll-domain/.../EmployeeTypes.kt`)
- Per-period time/earnings inputs are modeled via `TimeSlice` with:
  - regular and overtime hours
  - additional earning inputs
  - ability to suppress base earnings for off-cycle runs (`includeBaseEarnings=false`) (`payroll-domain/.../TimeTyp`
- Overtime behavior is policy-driven (`payroll-domain/.../OvertimePolicy.kt`).
- Explainability exists via trace types and trace levels (see `payroll-domain/.../TraceTypes.kt` and `payroll-domain/.../audit/TraceLevel.kt`).

Notes / gaps:

- "Full-time / part-time / shift" aren't explicit domain enums; they're represented via salary vs hourly + hours/proration + earning lines.
- More complex time rules (multiple rates, blended overtime, union rules, job costing) are not indicated as complete.

1.16.5 3.5 Earnings catalog and earnings types

Expected:

- Employer-defined earning codes mapped to semantic categories (regular, OT, bonus, etc.)
- Support for "supplemental" earnings and different tax treatments

In this repository:

- System-level earning categories exist (`EarningCategory` in `payroll-domain/.../CommonTypes.kt`).
- The engine supports arbitrary additional earning lines per period (`TimeSlice.otherEarnings`).
- Employer-specific earning definitions are abstracted behind a repository port (see `docs/employer-config.md`).

Notes / gaps:

- A full "earning configuration service/UI" is not present; current wiring uses in-memory repositories in services.

1.16.6 3.6 Deductions and employer contributions (benefits)

Expected:

- Pre-tax and post-tax deductions (401k, HSA/FSA, etc.)
- Employer contributions
- Caps and per-period limits

In this repository:

- Deduction configuration is expressed via ports and domain models (`docs/employer-config.md`).
- Golden tests exist for employer-specific deduction differences (referenced in `docs/employer-config.md`).

Notes / gaps:

- A production-grade benefits enrollment/config system and persistence is not shown.

1.16.7 3.7 Taxes: rule modeling, catalogs, and withholding

Expected:

- Federal income tax withholding
- FICA (SS/Medicare + Additional Medicare)
- State income tax withholding
- Local income taxes in select jurisdictions
- Employer taxes (FUTA/SUTA/SDI) depending on scope
- Yearly update workflow for statutory changes

In this repository:

- Tax rules are modeled as data (TaxRule/TaxContext) and served via `tax-service` (`tax-service/.../TaxRoutes.kt`).
- Tax content workflows exist:
  - Federal Pub 15-T wage bracket pipeline (see `docs/tax-content-operations.md`).
  - State income tax pipeline (CSV → JSON → DB) documented in `tax-service/README.md`.
- Employer-specific overlays are supported via `tax_rule.employer_id` and layered selection (`docs/employer-config.md`).
- Tests exist for federal withholding and for local/jurisdiction selection semantics (multiple golden tests under `tax-service/src/test`).

Notes / gaps:

- The repository README explicitly says coverage breadth and multi-year support are not complete (`README.md`).
- A payroll system typically needs broader tax surfaces (SUI/SDI, reciprocal agreements, local edge cases); this repository has the scaffolding and some coverage but is not presented as nationwide-complete.

1.16.8 3.8 Labor standards

Expected:

- Minimum wage (federal + state/local)
- Overtime thresholds and special rules
- Tipped wage / tip credit rules where applicable

In this repository:

- Labor standards are provided as a service boundary (`labor-service`) and maintained as CSV with deterministic JSON + SQL regeneration (`labor-service/README.md`).
- The domain has a tip-credit "make-up" enforcer for tipped employees given a labor standards context (`payroll-domain/.../TipCreditEnforcer.kt`).

Notes / gaps:

- Labor standards coverage is described as evolving; state/local complexity will require continued expansion.

1.16.9 3.9 Garnishments (including support)

Expected:

- Garnishment orders and withholding calculation

- Protected earnings floors, state-specific rules, and support caps
- Operational reconciliation and error handling

In this repository:

- Garnishment modeling and a substantial calculator + test suite exist in the domain (`payroll-domain/.../Garnishment` and tests).
- HR service owns garnishment orders and a ledger, including migrations and validation (`hr-service/.../garnishment/*` and `hr-service/src/main/resources/db/migration/hr/*garnishment*`).
- Worker service records withholding events back to HR; replay tooling and metrics exist (`payroll-worker-service/README.md`).

Notes / gaps:

- A fully "all states, all order types" garnishment product is typically extensive; this repository contains meaningful groundwork plus ops hooks.

1.16.10 3.10 Payruns (batch payroll execution)

Expected:

- Run payroll for many employees for a period
- Scale-out execution model
- Idempotent APIs and safe retries
- Clear "status" views and operator controls

In this repository:

- Orchestrator exposes payrun lifecycle endpoints with idempotency keys (`payroll-orchestrator-service/.../PayRunC`
- Execution is designed as queue-driven per-employee jobs (RabbitMQ) with DLQ and reconciliation workflows (see `docs/ops/payrun-jobs-observability.md` and `docs/ops/dlq-replay-reconciliation.md`).
- Worker has job controllers and internal replay mechanisms (guarded by internal auth).

Notes / gaps:

- This is one of the most production-oriented parts of the repository; the remaining gaps are more about "business breadth" and governance, not core mechanics.

1.16.11 3.11 Corrections: void, reissue, retro

Expected:

- Ability to void and reissue paychecks
- Retroactive adjustments when HR facts change
- Clear ledger semantics for downstream reporting

In this repository:

- VOID and REISSUE are implemented and documented (`docs/ops/payrun-corrections-void-reissue.md`).
- Retro adjustment workflows exist in orchestrator (tests indicate a workflow exists, e.g. `PayRunRetroAdjustmentWorkflo`
- Ledger semantics are formalized for downstream consumers (`docs/ops/reporting-filings-paycheck-ledger-events`

Notes / gaps:

- Corrections are currently modeled as deterministic clones/negations rather than re-computing from potentially changed historical inputs (explicitly called out as a limitation).

1.16.12 3.12 Payments / money movement

Expected:

- Payment initiation per paycheck

- Provider integration (ACH/check/wire) with safe handling of banking PII
- Reconciliation and lifecycle tracking

In this repository:

- Payments-service exists as system-of-record with a provider integration seam (`payments-service/.../provider/Payme`
- The seam explicitly avoids raw account/routing numbers; docs call for tokenization (`docs/ops/payments-provider-int`
- Orchestrator can rebuild projections from payments-service (internal reconciliation endpoints).

Notes / gaps:

- A real ACH/direct-deposit provider integration is not implemented here; the repository provides the seam and sandbox-like behaviors.

1.16.13 3.13 Reporting and filings

Expected:

- Stable payroll ledger for reporting and compliance
- Filing "shapes" (941/940/W-2/W-3, state summaries)
- Deterministic recomputation / audit support

In this repository:

- A stable paycheck ledger event contract is defined for downstream consumers (`docs/ops/reporting-filings-paycheck`
- Filings-service exposes endpoints for 941/940/W-2/W-3 and state withholding summaries (`filings-service/.../FilingsController.kt`).

Notes / gaps:

- Filing generation in practice requires deep validation, per-jurisdiction rules, and reconciliation with payments; this repository has early structure and integration seams.

1.16.14 3.14 Security and identity

Expected:

- Authentication and authorization at ingress
- Tenant scoping enforcement
- Privileged operation controls and audit logs

In this repository:

- Edge service enforces JWT-based authorization and employer scoping (`edge-service/.../EdgeAuthorizationFilter.`
- Internal privileged endpoints are guarded via internal auth (shared secret/JWT scaffolding) and security audit logging (`docs/security-boundary.md`, `docs/security-threat-model.md`).

Notes / gaps:

- `identity-service` module exists but is currently empty; production deployments need an IdP integration and hardened policies.

1.16.15 3.15 Observability and ops readiness

Expected:

- Metrics, logs, traces for core workflows
- Operator runbooks, SLOs, alerting

In this repository:

- SLO guidance and PromQL examples exist (`docs/ops/slo-core-workflows.md`).
- Payrun job observability is documented (`docs/ops/payrun-jobs-observability.md`).

- Trace propagation concepts are documented and OTLP config exists in service configs.

Notes / gaps:

- Production-grade dashboards/alerts and organization-specific on-call runbooks typically need tailoring, but the repository has strong starting templates.

1.16.16 3.16 Supply-chain and build quality

Expected:

- Dependency hygiene, vulnerability scanning, SBOMs

In this repository:

- Dependency locking + verification metadata and CI checks.
- OWASP Dependency-Check, Trivy, TruffleHog, CodeQL workflows exist under `.github/workflows/`.

1.17 4. Summary: what the repository "already is" vs "what remains"

Already present (strong foundation)

- Functional payroll engine with traceability
- Tax/labor content pipelines and year-update posture
- Garnishment modeling and ops hooks
- Queue-driven payrun execution with replay-safe primitives
- Payment integration seam with strong security stance on bank PII
- Filing/reporting contracts and early filing endpoints
- Security boundary plan + gateway enforcement model
- Multi-tenant DB-per-employer target + ops runbooks

Likely remaining work for a production payroll system

- Broader statutory coverage (state/local edge cases; multi-year backtesting)
- HR admin workflows and breadth hardening (more attributes, validations, and enterprise-grade audit/PII controls)
- Real payment provider integrations and settlement/returns pipelines
- Deeper filings compliance logic, validations, and reconciliation workflows
- Tenancy provisioning automation and hardened secrets management integration
- End-to-end identity/authorization integration across all services

A companion "prioritized gap list" aligned to a first enterprise go-live (P0/P1) can be produced by mapping this review to the enterprise-readiness capability register at `docs/ops/enterprise-readiness-capability-backlog.md`.