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RADIANT Expert System Adapters

Tenant-Trainable Domain Intelligence

Version: 1.0 | **January 2026**
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Executive Summary

Expert System Adapters (ESA) represent RADIANT's approach to tenant-trainable domain intelligence. Unlike generic AI models that treat all queries equally, ESA enables each tenant to build specialized AI expertise that continuously improves through interaction feedback.

Key Innovation: Every tenant develops their own "expert" that learns their specific domain language, preferences, and quality standards—without requiring any ML expertise from administrators.

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1. The Problem with Generic AI

1.1 One-Size-Fits-None

Traditional AI platforms offer the same model to all customers: - A law firm gets the same AI as a marketing agency - Medical terminology isn't prioritized for healthcare providers - Industry-specific jargon goes unrecognized - Quality standards vary by domain but models can't adapt

1.2 The Training Gap

Organizations want AI that understands them, but: - Fine-tuning requires ML expertise (costly, rare) - Training data curation is time-consuming - Model updates risk regression - No visibility into what the AI has "learned"

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2. Expert System Adapters: The Solution

2.1 Tri-Layer Architecture

ESA implements a three-layer adapter stack that composes personalization at multiple levels:

```
         Final Model Weights
  W_Final = W_Genesis + W_Cato + W_User






    Layer 0    Layer 1    Layer 2
    Genesis     Cato       User
     (Base)   (Global)   (Personal

     Frozen     Pinned    LRU Eviction
```

Layer	Name	Purpose	Management
0	Genesis	Base model weights	Frozen, never modified
1	Cato	Global constitution, safety, tenant values	Pinned in memory, never evicted
2	User	Personal preferences, interaction style	LRU eviction when memory constrained
3	Domain	Specialized expertise (optional)	Auto-selected by domain detection

2.2 Automatic Learning Pipeline

ESA learns from every interaction without manual intervention:

```
User Interaction



   Implicit        Training          Adapter
   Feedback           Candidate          Training
   Detection           Queue              Pipeline




                         Validation
                                         & Rollback
```

2.3 Feedback Signals

ESA captures both explicit and implicit quality signals:

Signal Type	Weight	Interpretation
Copy Response	+0.80	High utility - user copied the output
Thumbs Up	+1.00	Explicit positive feedback
Follow-up Question	+0.30	Partial success, needs more
Long Dwell Time	+0.40	User engaged with response
Regenerate Request	-0.50	Response wasn't satisfactory
Abandon Conversation	-0.70	Complete failure
Rephrase Question	-0.50	Original response missed the mark
Thumbs Down	-1.00	Explicit negative feedback

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3. Domain Expertise System

3.1 Domain Detection

RAWS (RADIANT Adaptive Weighted Selection) automatically detects query domains:

Domain	Subspecialties	Example Triggers
Legal	Contract, IP, Employment, Litigation	"pursuant to", "liability", "indemnify"
Medical	Clinical, Research, Administrative	"diagnosis", "contraindication", "ICD-10"
Financial	Accounting, Investment, Compliance	"GAAP", "depreciation", "quarterly"
Engineering	Software, Mechanical, Electrical	"API", "architecture", "implementation"
Creative	Marketing, Design, Content	"brand voice", "engagement", "campaign"
Research	Academic, Scientific, Analysis	"hypothesis", "methodology", "peer-reviewed"
Operations	HR, Project Management, Logistics	"workflow", "onboarding", "KPI"

3.2 Domain-Specific Adapters

Each domain can have specialized LoRA adapters:

```
interface DomainLoraAdapter {
  id: string;
  tenantId: string;
  domain: string;
  subdomain?: string;
  adapterName: string;
  baseModel: string;
  adapterVersion: number;
  s3Bucket: string;
  s3Key: string;
  trainingCandidatesCount: number;
  lastTrainedAt?: Date;
  accuracyScore?: number;
  domainRelevanceScore?: number;
  userSatisfactionScore?: number;
  status: 'training' | 'validating' | 'active' | 'deprecated' | 'failed';
}
```

3.3 Auto-Selection Algorithm

When a query arrives, ESA selects the optimal adapter:

```
Score = (0.3 × DomainMatch)
      + (0.1 × SubdomainBonus)
```

```
+ (0.25 × SatisfactionScore)
+ (0.1 × VolumeScore)
+ (0.05 × ErrorRate)
+ (0.2 × RecencyScore)
```

Selection threshold: Score 0.5 to use adapter (else fallback to base model)

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4. Training Pipeline

4.1 Candidate Collection

Training candidates accumulate based on configurable thresholds:

Setting	Default	Description
`min_candidates_for_training`	25	Minimum total candidates before training
`min_positive_candidates`	15	Minimum positive examples required
`min_negative_candidates`	5	Minimum negative examples for contrastive learning

4.2 Training Schedule

Configurable training frequency with intelligent scheduling:

Frequency	Best For	Auto-Optimal Time
Daily	High-volume tenants	Detects lowest-usage hours
Twice Weekly	Medium activity	Balances freshness/cost
Weekly	Standard deployments	Default for most tenants
Biweekly	Low activity	Conservative approach
Monthly	Minimal changes	Stability-focused

4.3 Contrastive Learning

ESA uses both positive and negative examples for better learning:

Positive Examples: High-rated responses, copied text, explicit thumbs-up **Negative Examples**: Regenerated responses, abandoned conversations, explicit thumbs-down

```sql
-- Negative learning candidate categories
'factual_error'       -- Incorrect information
'incomplete_answer'   -- Missing key details
'wrong_tone'          -- Inappropriate style
'too_verbose'         -- Unnecessarily long
'too_brief'           -- Lacking detail
'off_topic'           -- Didn't address question
'harmful_content'     -- Safety violation
'formatting_issue'    -- Poor structure
```

```
'code_error'          -- Broken code
'unclear_explanation' -- Confusing response
```

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5. Safety & Rollback

5.1 Automatic Rollback

ESA monitors adapter performance and automatically rolls back if quality degrades:

```
// Rollback triggers
const rollbackConditions = {
  satisfactionDrop: 10,     // % drop from baseline
  errorRateIncrease: 5,     // % increase in errors
  latencyIncrease: 50,      // % increase in response time
  minSampleSize: 100,       // Minimum requests before evaluation
};
```

5.2 A/B Testing

New adapters are deployed with gradual rollout: 1. **Shadow Mode** (0% traffic): Adapter runs but results not returned 2. **Canary** (5% traffic): Small percentage gets new adapter 3. **Gradual Rollout** (5% → 25% → 50% → 100%): Progressive increase 4. **Full Deployment**: All traffic uses new adapter

5.3 Version Control

Every adapter version is preserved: - Rollback to any previous version - Compare performance across versions - Audit trail of all training runs

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6. Implementation Files

6.1 Database Schema

Table	Purpose
`enhanced_learning_config`	Per-tenant configuration
`implicit_feedback_signals`	Captured feedback signals
`negative_learning_candidates`	Contrastive learning examples
`active_learning_requests`	User feedback requests
`domain_lora_adapters`	Domain-specific adapters
`domain_adapter_training_queue`	Training job queue
`adapter_usage_logs`	Adapter invocation tracking
`pattern_cache`	Successful response patterns

Migration: `packages/infrastructure/migrations/108_enhanced_learning.sql`

6.2 Services

Service	Purpose
`enhanced-learning.service.ts`	Core learning orchestration
`lora-inference.service.ts`	Tri-layer adapter inference
`adapter-management.service.ts`	Adapter selection and management

6.3 Admin API

Base: `/api/admin/learning`

Endpoint	Method	Purpose
`/config`	GET/PUT	Configuration management
`/domain-adapters`	GET	List domain adapters
`/domain-adapters/{domain}`	GET	Get active adapter for domain
`/training/queue`	GET	View training queue
`/training/trigger`	POST	Manually trigger training
`/performance/{adapterId}`	GET	Adapter performance metrics

6.4 Admin UI

Location: `/models/lora-adapters`

Features: - Tri-layer architecture visualization - Adapter registry by layer (Global/User/Domain) - Configuration management - Warmup controls - Performance metrics

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7. Competitive Advantages

7.1 vs. Generic AI Platforms

Capability	RADIANT ESA	Generic Platforms
Per-tenant customization	Automatic	Same model for all
Domain expertise	Learned	Generic
Implicit feedback	11 signal types	Manual ratings only
Contrastive learning	Positive + negative	Positive only
Automatic rollback	Built-in	Manual monitoring
Zero ML expertise required	Fully automatic	Requires ML team

7.2 vs. Custom Fine-Tuning

Aspect	RADIANT ESA	Custom Fine-Tuning
Time to value	Hours	Weeks-months
ML expertise needed	None	Senior ML engineer

Aspect	RADIANT ESA	Custom Fine-Tuning
Data curation	Automatic	Manual
Continuous learning	Always on	Batch retraining
Regression protection	Automatic rollback	Manual testing
Cost	Included	$50K-500K/year

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8. 2029 Vision

8.1 Short-term (2026)

- Tri-layer adapter architecture
- Implicit feedback detection
- Contrastive learning
- Automatic rollback
- Domain auto-selection

8.2 Medium-term (2027)

- Cross-tenant knowledge sharing (with privacy guarantees)
- Real-time adapter updates (no batch training)
- Multi-modal expertise (text, code, images)
- Expert marketplace for adapter sharing

8.3 Long-term (2029)

- Fully autonomous expertise development
- Zero-shot domain adaptation
- Cross-lingual expertise transfer
- Self-improving training pipelines

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9. Getting Started

9.1 Enable Expert System Adapters

1. Navigate to **Admin Dashboard → Models → LoRA Adapters**
2. Enable "LoRA Adapters" toggle
3. Configure adapter stacking options:
    - Use Global Adapter (Cato): Recommended ON
    - Use User Adapter: Recommended ON
    - Auto Selection: Recommended ON
4. Save configuration

9.2 Monitor Learning Progress

1. Check **Training Queue** for pending candidates
2. Review **Adapter Registry** for active adapters

3. Monitor **Performance Metrics** for quality trends
4. Use **Warmup** to pre-load frequently-used adapters

9.3 Domain Configuration

1. Navigate to **Learning → Domain Adapters**
2. View auto-detected domains with training candidates
3. Optionally trigger manual training for priority domains
4. Review adapter performance by domain

Expert System Adapters: Where every tenant becomes an AI domain expert.