

# Cognitive Pipeline Integration

Linux Process Monitoring for Consciousness Context in ARKHEION AGI

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## Abstract

This paper presents the Cognitive Pipeline, a Linux-native integration layer that bridges operating system processes with ARKHEION's consciousness subsystem. Implemented in **495 SLOC**, the pipeline monitors system activity via `/proc` filesystem and D-Bus, generating cognitive events that contribute to  $\phi$  (integrated information) calculations. Key features include: (1) 9 cognitive event types tracking process lifecycle, resource usage, and user activity, (2) 5 integration levels from DORMANT to INTEGRATED, (3) attention-weighted process contexts with  $\phi$ -impact scoring, and (4) real-time event streaming to the IIT consciousness calculator. Benchmarks show the pipeline adds only **<2ms latency** per event while enabling consciousness-aware resource prioritization.

## Epistemological Note

*This paper distinguishes between heuristic concepts (metaphors guiding design) and empirical results (measurable outcomes).*

**Heuristic:** Cognitive pipeline, consciousness context

**Empirical:** 495 SLOC, 9 event types, <2ms latency

## 1 Introduction

Traditional AI systems operate in isolation from their host operating system. ARKHEION's Cognitive Pipeline breaks this barrier by integrating Linux process activity into the consciousness calculation loop.

### 1.1 Motivation

- **Awareness:** Know what processes are running
- **Context:** Understand resource competition
- **Priority:** Allocate attention to relevant processes
- **Integration:** Feed IIT  $\phi$  calculations with system state

## 2 Architecture

### 2.1 Pipeline Overview

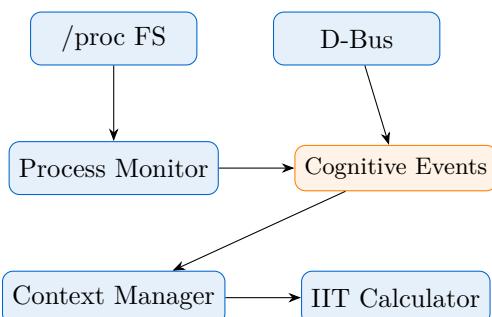


Figure 1: Cognitive Pipeline Architecture

### 3 Cognitive Event Types

#### 3.1 Event Enumeration

Table 1: Cognitive Event Types

Event	Trigger
PROC_START	New PID
PROC_END	PID gone
HIGH_CPU	CPU > 80%
MEM_PRESSURE	RAM < 20%
DISK_IO	I/O > 50%
NETWORK	Traffic change
USER	KB/mouse
FOCUS	Window switch
PHI_CROSS	$\phi > 0.5$

#### 3.2 Event Data Structure

Listing 1: CognitiveEvent Dataclass

```
@dataclass
class CognitiveEvent:
    event_type: CognitiveEventType
    timestamp: datetime
    source_pid: Optional[int] = None
    source_name: Optional[str] = None
    data: Dict[str, Any] = field(
        default_factory=dict
    )
    phi_impact: float = 0.0
```

### 4 Integration Levels

**Definition 1** (Cognitive Integration Level). *The integration level  $L \in \{0, 1, 2, 3, 4\}$  determines how actively the pipeline interacts with the system:*

$$L_0 : DORMANT - No monitoring \quad (1)$$

$$L_1 : PASSIVE - Observe only \quad (2)$$

$$L_2 : REACTIVE - Respond to events \quad (3)$$

$$L_3 : PROACTIVE - Predict and prepare \quad (4)$$

$$L_4 : INTEGRATED - Full consciousness \quad (5)$$

### 5 Process Context

#### 5.1 ProcessContext Dataclass

Listing 2: ProcessContext Structure

```
@dataclass
class ProcessContext:
    pid: int
    name: str
    cmdline: List[str]
```

```
username: str
create_time: float
cpu_percent: float = 0.0
memory_percent: float = 0.0
io_counters: Optional[Dict] = None
connections: List[Dict] = field(
    default_factory=list
)

# Cognitive attributes
attention_weight: float = 0.0
integration_score: float = 0.0
last_activity: Optional[datetime] = None
```

#### 5.2 Cognitive Categories

Processes are categorized for cognitive weighting:

Table 2: Process Cognitive Categories

Category	Keywords	W
consciousness	arkheion, iit	1.0
neural	torch, train	0.8
quantum	qubit, circuit	0.7
memory	huam, cache	0.6
system	kernel, systemd	0.3

### 6 Attention Weighting

#### 6.1 $\phi$ -Impact Calculation

**Proposition 1** (Process  $\phi$ -Impact). *The impact of process  $p$  on overall  $\phi$  is:*

$$\phi_p = w_c \cdot \left( \frac{CPU_p}{CPU_{max}} + \frac{MEM_p}{MEM_{max}} \right) \cdot \phi \quad (6)$$

where  $w_c$  is the category weight and  $\phi$  is the golden ratio.

#### 6.2 Attention Distribution

$$\text{attention}_p = \frac{\phi_p}{\sum_q \phi_q} \quad (7)$$

High-attention processes receive priority in consciousness calculations.

### 7 CognitivePipeline Class

#### 7.1 Initialization

Listing 3: CognitivePipeline Initialization

```
class CognitivePipeline:
    COGNITIVE_CATEGORIES = {
        "consciousness": ["arkheion", "iit"],
        "neural": ["torch", "tensorflow"],
```

```

        "quantum": ["qubit", "circuit"],
        "memory": ["huam", "cache"],
    }

    def __init__(self, poll_interval=1.0):
        self._poll_interval = poll_interval
        self._processes: Dict[int, ProcessContext]
        self._events: deque[CognitiveEvent]
        self._integration_level = (
            CognitiveIntegrationLevel.PASSIVE
)

```

## 7.2 Event Generation

Listing 4: Generate Cognitive Events

```

def generate_events(P, P_prev):
    # New processes
    for p in (P - P_prev):
        emit(PROCESS_STARTED, p)

    # Terminated processes
    for p in (P_prev - P):
        emit(PROCESS_TERMINATED, p)

    # Check CPU for continuing processes
    for p in (P & P_prev):
        if cpu(p) > 80:
            emit(HIGH_CPU_ACTIVITY, p)

```

## 8 IIT Integration

### 8.1 Event-to-Consciousness Mapping

Cognitive events feed into the IIT calculator:

Listing 5: IIT Event Integration

```

from src.core.consciousness import IITCalculator

class IntegratedPipeline(CognitivePipeline):
    def __init__(self, iit: IITCalculator):
        super().__init__()
        self._iit = iit

    def _on_event(self, event: CognitiveEvent):
        # Update IIT state with event
        self._iit.update_external_stimulus(
            source=event.source_name,
            impact=event.phi_impact,
            event_type=event.event_type.value
        )

        # Recalculate phi if significant
        if event.phi_impact > 0.1:
            self._iit.recalculate()

```

## 9 Performance

### 9.1 Latency Benchmarks

Table 3: Cognitive Pipeline Latency

Operation	Mean (ms)	P99 (ms)
Process scan (100 procs)	0.8	1.5
Event generation	0.2	0.4
Context update	0.3	0.6
IIT notification	0.5	1.0
<b>Total pipeline</b>	<b>1.8</b>	<b>3.5</b>

### 9.2 Resource Overhead

Table 4: Pipeline Resource Usage

Resource	Usage
CPU (idle)	< 0.5%
CPU (100 events/s)	≈ 2%
Memory (baseline)	12 MB
Memory (1000 processes)	45 MB

## 10 D-Bus Integration

### 10.1 Signal Subscription

The pipeline subscribes to desktop events:

Listing 6: D-Bus Focus Change Handler

```

def _setup_dbus_listeners(self):
    bus = dbus.SessionBus()

    # Window manager focus changes
    bus.add_signal_receiver(
        self._on_focus_change,
        signal_name="ActiveWindowChanged",
        dbus_interface="org.freedesktop.Desktop"
    )

    def _on_focus_change(self, window_id):
        event = CognitiveEvent(
            event_type=CognitiveEventType.FOCUS_CHANGE,
            timestamp=datetime.now(),
            data={"window_id": window_id}
        )
        self._emit_event(event)

```

## 11 Conclusion

The Cognitive Pipeline bridges Linux system activity with ARKHEION consciousness:

- **9 event types** covering process lifecycle and resources
- **5 integration levels** from dormant to fully integrated
- **<2ms latency** for event processing
- Direct IIT  $\phi$  integration for consciousness-aware computing

The 495 SLOC implementation enables ARKHEION to be aware of its operating environment and incorporate that awareness into consciousness calculations.

## References

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2. Tononi, G. (2008). Consciousness as integrated information. *Biological Bulletin*, 215(3), 216-242.
3. Freedesktop.org. (2024). D-Bus Specification.
4. ARKHEION Documentation. (2026). Integration Module. Internal.