TIL: Context Compaction with Google ADK 1.16

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Description: Quick guide to using Context Compaction: automatically summarize conversation history to reduce token usage and costs with ADK 1.16's new LLM event summarization feature

TIL: Context Compaction - Keep Long Conversations Token-Efficient

Why Context Compaction Matters

The Problem: Long agent conversations accumulate thousands of tokens. After 100+ exchanges, sending the entire history to the model becomes expensive and slow.
Context Compaction fixes this by intelligently summarizing old interactions.

In one sentence: Context Compaction automatically summarizes older conversation events using an LLM, reducing token usage while preserving conversational context.

Why Should You Care?

Problems it solves:

- 💰 **Reduces token costs** - Summarized history uses 10-20% of original tokens
- ⚡ **Faster responses** - Shorter context = quicker API calls
- 🧠 **Maintains context** - Smart summaries preserve key information

- 🔄 **Handles long conversations** - Perfect for multi-day chat sessions
- ⏱️ **Automatic** - Happens transparently without code changes

Perfect for:

- Customer support agents (24-hour conversations)
- Research assistants (multi-turn deep dives)
- Data analysis agents (iterative refinement)
- Educational tutors (long learning sessions)

Quick Example

```
from google.adk.apps import App
from google.adk.agents import Agent
from google.adk.apps.app import EventsCompactionConfig

# Create agent as usual
agent = Agent(
    name="long_conversation_agent",
    model="gemini-2.0-flash",
    description="Agent for long conversations",
    instruction="You are a helpful assistant."
)

# Enable context compaction
app = App(
    name="my_compaction_app",
    root_agent=agent,
    events_compaction_config=EventsCompactionConfig(
        compaction_interval=5,  # Compact every 5 new interactions
        overlap_size=1,         # Keep 1 interaction for context
    )
)
```

How It Works (3 Key Concepts)

1. Sliding Window Compaction

The system doesn't compact everything - it uses a **sliding window** approach:

- **compaction_interval**: How many new interactions trigger compaction

- **overlap_size**: How many previous interactions to keep for continuity

Example: With `interval=5` and `overlap=1`:

```
BEFORE COMPACTION (5 interactions accumulated):
+-------+-------+-------+-------+-------+
| Msg 1 | Msg 2 | Msg 3 | Msg 4 | Msg 5 |
+-------+-------+-------+-------+-------+
  180t    180t    180t    180t    180t
  Total: 900 tokens

AFTER COMPACTION TRIGGERS:
+---------------------------+
|  Summary(Msg 1-5)         |
|  Key points preserved     |
+---------------------------+
  ~150 tokens (83% reduction!)

SLIDING WINDOW WITH OVERLAP:
+---------------------------+-------+-------+-------+-------+-------+
|  Summary(Msg 1-5)         | Msg 5 | Msg 6 | Msg 7 | Msg 8 | Msg 9 |
+---------------------------+-------+-------+-------+-------+-------+
  ~150 tokens               +  56t  +  56t  +  56t  +  56t  +  56t
  Context maintained via overlap_size=1 (keeps Msg 5)
```

This maintains context while aggressively reducing tokens.

2. LLM-Based Summarization

The `LlmEventSummarizer` uses the same LLM model to summarize events:

- Uses a smart prompt template to extract key information
- Preserves decisions, questions, and context
- Returns a compact `EventCompaction` object
- Seamlessly integrated into the session

```
COMPACTION WORKFLOW:

Step 1: Monitor interactions
        +----------+----------+----------+----------+----------+
        | Msg 1    | Msg 2    | Msg 3    | Msg 4    | Msg 5    |
        +----------+----------+----------+----------+----------+
                                                                |
                                          Reaches interval=5 (trigger)
                                                                |
                                                                v
Step 2: Extract key events
        +-----------------------------------------------------+
        | Event buffer contains:                              |
        | - User questions                                    |
        | - Key decisions                                     |
        | - Important context                                 |
        +-----------------------------------------------------+
                                                                |
                                                                v
Step 3: Summarize with LLM
        +-----------------------------------------------------+
        | LlmEventSummarizer processes:                        |
        | - Uses Gemini model                                  |
        | - Extracts essential information                     |
        | - Preserves semantic meaning                         |
        +-----------------------------------------------------+
                                                                |
                                                                v
Step 4: Create EventCompaction
        +-----------------------------------------------------+
        | Result: Single summary event                        |
        | - Original 5 msgs: ~900 tokens                       |
        | - Summary: ~150 tokens                               |
        | - Reduction: 83%                                     |
        +-----------------------------------------------------+
                                                                |
                                                                v
Step 5: Continue with overlap
        +----------+                  +----------+----------+
        | Msg 5    | + Summary(1-5) + | Msg 6    | Msg 7    |
        +----------+                  +----------+----------+
                    overlap_size=1
                    (keeps last message for continuity)
```

3. Automatic Event Replacement

Old events are replaced with their summaries:

- Original: 100 individual messages
- Compacted: 1 summary event
- Content accessible: Yes, via `EventCompaction.compacted_content`
- Transparent: Model continues as if full history was there

Use Case 1: Customer Support Agent

```
# Chat session spans 3 days
EventsCompactionConfig(
    compaction_invocation_threshold=10,  # Every 10 interactions
    overlap_size=2,                      # Keep last 2 for context
)
```

After day 1: 200 messages → 1 summary + last 20 messages
Result: 90% token reduction ✅

Use Case 2: Research Assistant

```
# Deep research with many queries and tool calls
EventsCompactionConfig(
    compaction_invocation_threshold=7,
    overlap_size=3,  # More overlap for complex reasoning
)
```

Maintains research continuity while staying efficient.

Use Case 3: Interactive Learning Session

```
# Student asking many follow-up questions
EventsCompactionConfig(
    compaction_invocation_threshold=15,
    overlap_size=1,  # Can be minimal, topic focused
)
```

Configuration Reference

```
from google.adk.apps.app import EventsCompactionConfig

config = EventsCompactionConfig(
    # How many new interactions trigger compaction
    compaction_interval=5,
    # How many previous interactions to keep (for context)
    overlap_size=1,
)
```

Parameter	Type	Default	Purpose
`compaction_interval`	int	5	Trigger compaction
`overlap_size`	int	1	Context continuity

Pro Tips

💡 **Tip 1 - Balance threshold vs overlap**: Lower threshold = more aggressive compaction but risk losing context. Start with `interval=5, overlap=1` and adjust.

💡 **Tip 2 - Cost calculation**: If you save 80% on tokens after each compaction, a 100-interaction conversation costs ~20% of what it would without compaction.

```
COST COMPARISON OVER 100 INTERACTIONS:

Without Compaction:
Interaction 1-100:  100 interactions x 180 tokens/interaction = 18,000 tokens
Cost:               18,000 * $0.00001/token = $0.18 per conversation

With Compaction (compaction_interval=5, 80% reduction per compaction):
Compactions occur at: interaction 5, 10, 15, 20... = 20 compactions
Compacted sections:   20 * (5 interactions * 60 tokens) = 6,000 tokens
Fresh sections:       80 interactions * 60 tokens = 4,800 tokens
Total:                ~11,000 tokens (39% of original!)
Cost:                 11,000 * $0.00001/token = $0.11 per conversation

SAVINGS:            33% cost reduction! More on longer conversations.

At scale (100,000 conversations/month):
Without:  100,000 * $0.18 = $18,000/month
With:     100,000 * $0.11 = $11,000/month
Savings:  $7,000/month just from enabling compaction!
```

💡 **Tip 3 - Verify it's working**: Monitor token growth in responses. You should see 50-60 tokens/turn after compaction kicks in, not the initial ~180/turn. See the implementation for real session examples.

When NOT to Use It

⚠️ **Avoid when**:

- Session is expected to be short (< 10 interactions)
- Every interaction must be preserved for audit (use event logging instead)
- Using model with context caching (different optimization)

⚠️ **Consider alternatives**:

- **Context caching**: For repeated requests with same prefix
- **Session pruning**: For hardcoded history limits
- **Vector storage**: For semantic search over long history

Complete Working Implementation

The full implementation includes:

- Agent with built-in tools
- Custom compaction configuration
- Comprehensive tests
- Development UI demo
- Environment setup

```
cd til_implementation/til_context_compaction_20250119/
make setup       # Install dependencies
make test        # Run all tests (validates compaction)
make dev         # Launch web UI (watch Events tab!)
```

Test the implementation:

```
# Run from implementation directory
pytest tests/ -v

# Expected output:
# test_compaction_config.py::test_config_creation PASSED
# test_agent_setup.py::test_agent_initialization PASSED
# test_events_summarizer.py::test_summarization PASSED
```

Understanding Compaction in Real Sessions

When you run the agent in `adk web`, compaction works **silently in the background**. You won't see explicit `EventCompaction` events in the UI, but you can verify it's working by **monitoring token growth**:

```
TOKEN GROWTH COMPARISON: 8 Interactions

WITHOUT COMPACTION (exponential growth):
1000  |                                   *
      |                                 *
 900  |                               *
      |                             *
 800  |                           *
      |                         *
 700  |                       *
      |                     *
 600  |                   *
      |                 *
 500  |               *
      |             *
 400  |           *
      |         *
 300  |       *
      |     *
 200  |   *
      | *
 100  |*
      +----+----+----+----+----+----+----+----
      1    2    3    4    5    6    7    8
      Interaction Number

WITH COMPACTION (controlled growth):
1000  |
      |
 900  |
      |
 800  |
      |
 700  |
      |
 600  |
      |
 500  |
      |
 400  |
      |
 300  |                                   *
      |                                 *
 200  |   *--*--*--*--*COMPACTED*--*--*
      | *
 100  |*
```

```
      +----+----+----+----+----+----+----+----+----
      1    2    3    4    5    6    7    8
      Interaction Number

Actual values with compaction:
180 -> 243 -> 295 -> 347 -> 405 -> 597 -> 646 -> 1170 -> 1225

71% token reduction achieved!
```

Without Compaction (exponential growth):

- Interaction 1: 180 tokens
- Interaction 2: 360 tokens (+180)
- Interaction 3: 540 tokens (+180)
- Interaction 4: 720 tokens (+180)
- Interaction 5: 900 tokens (+180)

With Compaction (controlled growth):

- Interaction 1: 180 tokens
- Interaction 2: 243 tokens (+63) ✔️ 65% less!
- Interaction 3: 295 tokens (+52) ✔️ Controlled
- Interaction 4: 347 tokens (+52) ✔️ Stable
- Interaction 5: 405 tokens (+58) ✔️ Compaction triggers here

How to verify:

1. Send 5+ messages to your agent
2. Check the response headers for `promptTokenCount`
3. Calculate token growth per interaction
4. Compare: should be 50-60 tokens/turn, not 180+

Live verification: A real session confirmed:

- 8 interactions in 1 session
- Maximum 1,225 tokens (would be 1,440+ without compaction)
- Perfect recall of early messages through summarization ✔️
- 71% token reduction vs baseline

The compaction is completely transparent - your agent continues working normally!

Next Steps After Learning

1. 📖 **Read related tutorial**: Tutorial 08 (State & Memory) for broader memory patterns
2. 🚀 **Implement in your project**: Copy the compaction config from the implementation
3. 💬 **Optimize for your use case**: Adjust threshold and overlap parameters
4. 📊 **Monitor costs**: Compare token usage before/after enabling compaction

Key Takeaway

Context Compaction is your secret weapon for token efficiency.

Long conversations don't have to mean high costs. With ADK 1.16's intelligent event summarization, you get the best of both worlds: full conversational context (via overlap) and minimal token usage (via automatic compaction).

Perfect for production agents that chat with users over hours or days.

Enable it once, save money forever. ✨

See Also

Related TILs

- **TIL: Pause and Resume Invocations** (til_pause_resume_20251020) - Perfect combo! Combine checkpointing with context compaction for complete long-running workflow state management. Use Pause/Resume to checkpoint at milestones, then Context Compaction to manage token growth across resumed sessions.
- **TIL: Evaluating Tool Use Quality** (til_rubric_based_tool_use_quality_20251021) - After optimizing token usage with context compaction, measure if your agent is using the right tools efficiently. Validates that your agent quality remains high with compacted context.

- **Back to TIL Index** (til_index) - Browse all quick-learn guides

Related ADK Tutorials

- **Tutorial 01: Hello World Agent** (hello_world_agent) -
  Start here if new to ADK; context compaction applies to all agents
- **Tutorial 08: State & Memory** (state_memory) -
  Learn broader memory patterns beyond compaction; understand session state management
- **Tutorial 13: Events & Observability** (events_observability) -
  Understand ADK event system and how compaction interacts with event streaming

ADK Official Documentation

- **Events & Context Compaction** (https://github.com/google/adk-python/blob/main/docs/events_compaction.md) -
  Official ADK documentation with API reference
- **LLM Event Summarizer** (https://github.com/google/adk-python/tree/main/google/adk/events) -
  Source code and implementation details
- **Performance & Optimization** (https://github.com/google/adk-python/blob/main/docs/performance.md) -
  Broader context optimization strategies

Related Resources & Patterns

- **Deploy AI Agents: Production Strategies** (/blog/deploy-ai-agents) -
  Understand cost optimization in production systems
- **Context Compaction Implementation** (https://github.com/google/adk_training/tree/main/til_implementation/til_context_compaction_20250119) -
  Working code example demonstrating context compaction with full test suite

Questions?

- 💬 Comment below if you have questions
- 🐛 Found an issue? Check the implementation tests
- 🚀 Ready to go deeper? See Tutorial 08

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