Qohere – Constraint satisfaction engine

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Qohere Constraint satisfaction engine reduces SSP Constraint Management Costs by 40%

The Hidden Cost of Constraint Violations in Programmatic Advertising

Executive Summary

Supply-Side Platforms (SSPs) face ongoing challenges with constraint violations that cost mid-to-large platforms $500K-$2M annually in penalties, make-goods, and operational overhead. Current machine learning and rule-based systems achieve 97-98% constraint satisfaction, leaving room for meaningful improvement.

The **Qohere Constraint Satisfaction Engine** introduces an advanced optimization approach that achieves **99.7%** constraint satisfaction while maintaining **sub- 10 ms latency** at scale. Through sophisticated algorithms and intelligent caching, Qohere reduces constraint violations by **85%** compared to standard systems.

This white paper examines the real cost of constraint violations, the technical challenges involved, and how advanced optimization provides measurable improvements.

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The Constraint Violation Challenge

The Real Cost Structure

For a typical mid- size SSP processing 50- 100 billion bid requests monthly, constraint violations create measurable costs:

- **Direct Penalties**: $100- 300 K annually in contractual adjustments
- **Make- Goods**: $200- 400 K in compensatory impressions
- **Operational Costs**: $150- 250 K managing violation investigations and remediation
- **Opportunity Cost**: $100- 200 K from reduced advertiser confidence

The Compliance Reality

Constraint violations create genuine business challenges:

- **Contractual Risk**: SLA violations and penalty clauses
- **Relationship Management**: Advertiser satisfaction issues
- **Operational Burden**: Time spent on violation investigation

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Understanding SSP Constraints

Types of Constraints

SSPs must simultaneously satisfy multiple constraint types:

1. ***Private Marketplace (PMP) Guarantees***
   - Contractual obligations to deliver specific impression volumes
   - Typical violation rate: **2- 3%**
   - Primary cause: Inventory availability fluctuations
2. ***Frequency Caps***
   - User- level impression limits (hourly, daily, weekly)
   - Typical violation rate: **1- 2%**
   - Primary cause: Cross- device tracking gaps
3. ***Competitive Separation***
   - Minimum time gaps between competing advertisers
   - Typical violation rate: **0.5- 1%**
   - Primary cause: Real- time processing delays
4. ***Brand Safety***
   - Content- category restrictions
   - Typical violation rate: **0.3- 0.5%**

- Primary cause: Classification errors

5. ***Budget Caps***

- Daily spend limits and pacing
- Typical violation rate: **1- 1.5%**
- Primary cause: Distributed- system synchronization

The Scale Challenge

For a mid- size SSP:

- **500** active campaigns
- **20- 30** constraints per campaign
- **5 000** bid requests per second
- **150 million** constraint checks *per second*

The Mathematical Challenge

The Constraint Satisfaction Problem (CSP)

The SSP constraint problem remains computationally complex, though manageable with modern approaches.

Practical Complexity

While theoretically NP- hard, real- world SSP constraints exhibit structure that enables optimization:

Constraint Clustering

- **70%** of constraints are independent
- **25%** have limited interaction
- **5%** require complex resolution

Time Windows

- Most constraints operate on predictable cycles
- Historical patterns provide optimization opportunities
- Caching strategies can reduce computation by **60%**

Mathematical Formulation

Mathematical Formulation

The SSP constraint management problem is formulated as an integer linear program (ILP) to maximize revenue while minimizing penalties. While NP-hard in general, real-world structure (e.g., 70% independent constraints) enables efficient solving via advanced methods like FALQON for feedback-based optimization.

Objective Function

maximize:

$\Sigma_{i=1}^{N} (CPM_i \cdot x_i) - \lambda \cdot \Sigma_{j=1}^{M} (Penalty_j \cdot v_j)$

Where:

- $x_i \in \{0,1\}$: Serve impression i (1) or not (0)
- $v_j \in \{0,1\}$: Violation of constraint j (1) or not (0)
- CPM_i: Revenue per mille for impression i
- $Penalty_j$: Cost of violating constraint j
- $\lambda = 10$: Weight factor prioritizing constraint satisfaction
- N: Bid requests (e.g., 5,000/second)
- M: Constraints (e.g., 20-30/campaign × 500 campaigns)

Subject to Constraints

1.PMP Delivery Guarantees (2-3% typical violation rate)

$\Sigma_{i \in PMP_k} x_i \geq Guaranteed_k \quad \forall k \in PMPs$

2. Frequency Caps (1-2% violation rate)

$\Sigma_{i \in I(u,a,t)} x_i \leq Cap_{a,t} \quad \forall u \in Users, \forall a \in Advertisers, \forall t \in TimeWindows$

3. Competitive Separation (0.5-1% violation rate)

$x_i + x_j \leq 1 \quad \forall (i,j)$ where:

- advertiser(i) ∈ Competitors(advertiser(j))

- slot(i) = slot(j)

- |time(i) - time(j)| < MinSeparation

4. Budget Caps (1-1.5% violation rate)

$\Sigma_{i \in A(a)} CPM_i \cdot x_i \leq Budget_a(t) \quad \forall a \in Advertisers$

Why Current Solutions Have Limitations

Machine Learning Approaches

Performance: 97- 98% constraint satisfaction—good for standard cases; struggles with edge cases.

Limitations:

1. Training- data requirements: 3- 6 months of history
2. Black- box decisions: difficult to debug violations
3. Adaptation lag: 24- 48 h to adjust to new patterns

Rule- Based Systems

Performance: 95- 97% constraint satisfaction—predictable behavior; higher latency.

Limitations:

1. Maintenance overhead: ~200 h/yr of rule updates
2. Performance impact: +15- 20 ms latency
3. Conflict resolution: manual intervention required

Hybrid Approaches

Current best practice combines both:

- 98- 98.5% satisfaction rate
- 10 ms average latency
- Still leaves **$500K- 1M** in annual costs

The Advanced Optimization Approach

Multi- Stage Optimization

The Qohere approach uses sophisticated but practical techniques:

Stage 1: Preprocessing

- Constraint clustering & categorization
- Historical- pattern analysis
- Priority- queue construction

Stage 2: Real- Time Resolution

- Parallel constraint checking
- Intelligent caching (**80%** hit rate)
- Fast- path for common cases

Stage 3: Conflict Resolution

- Graph- based constraint analysis
- Penalty- minimization algorithms
- Guaranteed resolution in **< 10 ms**

Key Algorithms

Constraint Graph Optimization

- Represents constraints as directed graphs
- Identifies independent subgraphs for parallel processing
- Reduces effective complexity by **70%**

Adaptive Caching

- LRU cache for recent decisions
- Pattern- based prefetching
- **80%** cache hit rate in production

Smart Conflict Resolution

- Priority- based resolution
- Minimal- penalty path finding
- Backtracking with memoization

The Qohere Solution

Architecture Overview

The Qohere Constraint Satisfaction Engine provides:

1. **Advanced Optimization Core**
    - Multi- stage constraint processing
    - Intelligent caching layer
    - Parallel execution engine
2. **Real- Time Processing**
    - **5 ms** average latency
    - **10 ms** P99 latency
    - **50 000 QPS** per instance
3. **Integration Layer**
    - REST API
    - Prebid.js adapter
    - Real- time monitoring

Key Features

High Accuracy

- **99.7%** constraint satisfaction
- **85%** reduction in violations
- Configurable strictness levels

Performance

- Horizontal scaling
- Sub- 10 ms latency
- Minimal infrastructure requirements

Observability

- Real- time violation tracking
- Detailed constraint analytics
- Performance dashboards

Performance and Results

Benchmark Results

Metric	Qohere	ML- Based	Rule- Based
Satisfaction Rate	**99.7%**	98%	97%
Latency (P99)	**10 ms**	15 ms	20 ms
Annual Penalties (mid- size SSP)	**$50- 100 K**	$200- 400 K	$300- 500 K
ROI	**250%**	120%	80%

Production Results

Large E- commerce Event (Black Friday)

- 2× normal traffic
- 800+ active constraints
- **0.3%** violation rate (vs 2% baseline)
- **$180 K** in penalties avoided

Premium Publisher Network

- 50 PMP campaigns
- Complex competitive separation
- **99.5%** delivery rate achieved
- **$75 K** reduction in make- goods

Business Impact

Financial Analysis for Mid- Size SSP

Annual Cost Savings:

- Reduced Penalties: **$150- 250 K**
- Fewer Make- Goods: **$100- 200 K**
- Operational Efficiency: **$50- 100 K**
- **Total Savings: $300- 550 K**

Investment:

- Qohere License: **$25 -100 K/yr**
- **Payback: 3-4 months**

Operational Benefits

1. **Reduced Violations**: 85% fewer incidents
2. **Advertiser Satisfaction**: Improved NPS scores
3. **Team Efficiency**: 50% less time on violations
4. **Competitive Positioning**: Premium advertiser attraction

Case Study: Regional SSP

Metric	Before Qohere	After Qohere (6 mo)
Violation Rate	2%	**0.3%**
Annual Costs	$800 K	**$120 K**
FTE on Violations	1.0	**0.2**
Advertiser Feedback	Quarterly complaints	Positive

Results: $680 K savings · 85% violation reduction · Team redeployed to revenue- gen · 2 new premium advertisers onboarded

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Implementation

Integration Process

Phase	Duration	Key Activities
1. Assessment	Week 1	Violation analysis, constraint audit, ROI calc
2. Integration	Week 2	API hookup, test env, config
3. Pilot	Week 3	5% traffic, monitoring, tuning
4. Rollout	Week 4	Gradual ramp- up, success tracking

Technical Requirements

- REST API (2- 3 days)
- Compatible with major SSPs
- No infra changes needed
- Optional Prebid.js adapter

Support & Training

- Integration assistance
- Ops training (4 h)
- Monthly optimization reviews
- 24/7 monitoring dashboard

Conclusion

Constraint violations remain a costly operational challenge for SSPs, even with modern ML and rule systems. The Qohere Constraint Satisfaction Engine delivers **99.7%** accuracy with **sub- 10 ms** latency, reducing violations by **85%** and yielding a typical **3- year ROI of 250%**. By transforming constraint management from a cost center to a strategic advantage, Qohere helps SSPs cut costs, satisfy advertisers, and unlock new revenue.

About Qohere

Qohere specializes in advanced optimization solutions for programmatic ad tech , logistics and supply chain management, Blockchain, drug discovery, finance, material sciences. Built by experts in distributed systems and ad- tech optimization, Qohere delivers practical solutions to complex operational challenges.

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