**APEAFAST-SG Clear Path Gateway Solution Design**

**Phase 1: Singapore Fast Payment Modernization**

**1. Executive Summary**

The APEAFAST-SG Clear Path Gateway is a comprehensive cloud-native payment processing platform that replaces GPP G3 for Singapore's faster payment system. The solution spans both on-premises and cloud regions, providing end-to-end payment processing capabilities with integrated liquidity management, real-time monitoring, and operational excellence.

**2. Architecture Overview**

The solution follows a hybrid architecture model with three distinct regions:

**On-Premise Region:**

* PSP Global (Debit/Batch Processing)
* Core banking integration (VAM, MIDANZ, LMS)
* Legacy system interfaces

**Cloud Region:**

* PSP APEA FAST - SG Connector
* SG Gateway Services
* Liquidity Management capabilities
* Event processing and monitoring

**External Region:**

* G3 Host integration
* CPG connectivity
* External scheme interfaces

**3. Core Service Architecture**

**3.1 PSP APEA FAST - SG Connector (Cloud Region)**

**Outward Clearing Request Services**

* Payment request ingestion from PSP Global
* Business rule validation
* Routing to appropriate clearing services

**Payment Orchestration**

* Payment workflow management
* State management and tracking
* Exception handling coordination

**Clearing Schemes Services**

* Scheme-specific processing logic
* Message transformation and validation
* Protocol adaptation for different payment types

**Direct Debit Processing**

* PACS.003 message handling and validation
* Customer account liquidity verification
* Pre-debit authorization checks
* Account debit processing coordination
* PACS.007 reversal handling
* CAMT.056/029 cancelation processing

**Liquidity Authorization Services**

* Real-time liquidity checking for outward payments
* Customer account balance verification for DDI
* Authorization decision engine
* Hold and retry mechanisms
* Net debit cap impact calculations

**General Clearing Generation Services**

* Message construction for outbound payments
* Format standardization
* Header and metadata management

**Payment Response**

* Response processing from clearing networks
* Status updates and notifications
* Callback management to PSP Global

**3.2 SG Gateway Services (Cloud Region)**

**SG Fast Router**

* Message reception from CPG/G3 Host
* Initial validation and parsing
* Routing decisions based on message type
* Duplicate detection and handling

**Message ID Generation & Message Enrichment**

* Unique message identifier creation
* Message correlation and tracking
* Enrichment with business context
* Audit trail initiation

**Generate MUID**

* Message Unit ID generation
* Cross-reference management
* Message lifecycle tracking

**Message Handling**

* Protocol-specific message processing
* Format conversion and transformation
* Error handling and recovery

**Timer Handling**

* SLA timer management (4.5 seconds for inward)
* Timeout detection and escalation
* Performance monitoring

**3.3 Business Services Integration**

**PSP APEA FAST - Business Services**

* Account validation and verification
* Customer verification processes
* Business rule enforcement
* ~~Fraud checking integration~~

**Account Services**

* Account lookup and validation
* Account status verification
* Account holder information retrieval

**4. Data and Event Management**

**4.1 Payment Data Hub**

* Centralized payment data management
* Real-time data synchronization
* Data quality and consistency management
* Historical data archival

**4.2 Event Processing**

**Payment Events**

* Real-time payment status events
* Lifecycle event management
* Event correlation and aggregation

**Payment Message Queue**

* Asynchronous message processing
* Message ordering and sequencing
* Retry and dead letter handling

**Credit Notifications**

* Customer notification triggers
* Multi-channel notification support
* Delivery confirmation tracking

**Data Sync - Account Feed**

* Account data synchronization
* Real-time updates from core systems
* Data consistency maintenance

**Bank Availability**

* Participant bank status tracking
* Real-time availability updates
* Service interruption notifications

**Bank Availability Update**

* Automated status refresh
* Manual override capabilities
* Historical availability tracking

**4.3 Liquidity Management Services**

**Liquidity Tracker/Management**

* Real-time balance calculation
* Net debit cap monitoring
* Settlement cycle tracking
* Threshold management

**Liquidity Authorization Check & Update**

* Pre-transaction authorization
* Balance reservation and release
* Authorization audit trail

**Bank Liquidity Management**

* Multi-bank liquidity aggregation
* Cross-border liquidity optimization
* Regulatory compliance monitoring

**5. External Integration Architecture**

**5.1 G3 Host Integration**

* **Inbound Flows:**
  + PACS.008 (Credit Transfer Initiation)
  + PACS.003 (Direct Debit Initiation)
  + CAMT.056 (Cancelation Request)
  + PACS.007 (Reversal Request)
  + SNM messages (Settlement, Bank Status, etc.)
* **Outbound Flows:**
  + PACS.002 (Payment Status Report - Accept/Reject)
  + PACS.008 (Outward Credit Transfer)
  + CAMT.029 (Cancelation Response)
  + Administrative messages (Sign-on/Sign-off)
* **Protocol:** MQ-based messaging via CPG
* **SLA:** 4.5 seconds for inward processing (CTI and DDI)

**5.2 CPG (Clearing Payment Gateway) Integration**

* Message routing and transformation
* Security and encryption handling
* Protocol translation
* Connection management with G3 Host

**5.3 Core Banking Integration**

**VAM (Virtual Account Management)**

* Virtual account processing
* Account mapping and resolution
* Balance inquiries and updates

**MIDANZ**

* Core banking transaction processing
* Account posting and settlement
* Real-time balance updates

**LMS (Liquidity Management System)**

* Legacy liquidity interfaces
* Settlement reporting
* Regulatory compliance data

**6. Operational and Monitoring Services**

**6.1 Real-time Monitoring**

* Transaction flow monitoring
* System health dashboards
* Performance metrics tracking
* SLA compliance monitoring

**6.2 Exception Management**

* Failed transaction handling
* Manual intervention interfaces
* Escalation workflows
* Resolution tracking

**6.3 Audit and Compliance**

* Complete transaction audit trails
* Regulatory reporting capabilities
* Data retention management
* Compliance monitoring dashboards

**7. Payment Flow Implementation**

**7.1 Inward Credit Transfer Flow**

1. **Message Reception**: G3 Host → CPG → SG Fast Router
2. **Validation & Enrichment**: Message validation, MUID generation, duplicate check
3. **Business Processing**: Route to PSP APEA FAST Business Services
4. **Account Processing**: Account validation, posting via VAM/MIDANZ
5. **Response Generation**: PACS.002 creation and transmission
6. **Liquidity Update**: Real-time balance adjustment
7. **Notification**: Customer notification via P-ReX

**7.2 Outward Credit Transfer Flow**

1. **Request Reception**: PSP Global → Outward Clearing Request Services
2. **Liquidity Authorization**: Check available liquidity before processing
3. **Message Construction**: Generate PACS.008 via General Clearing Generation Services
4. **Transmission**: Send to G3 Host via CPG
5. **Response Handling**: Process PACS.002 confirmation
6. **Status Update**: Update PSP Global with transaction status
7. **Liquidity Reconciliation**: Final balance adjustment

**7.3 Direct Debit Inward (DDI) Flow**

1. **Message Reception**: G3 Host → CPG → SG Fast Router (PACS.003)
2. **Validation & Processing**: Message validation, MUID generation, scheme validation
3. **Liquidity Check**: Validate customer account has sufficient funds for debit
4. **Authorization**: Pre-authorization check before account debit
5. **Account Debit**: Process customer account debit via VAM/MIDANZ
6. **Response Generation**: Send PACS.002 (acceptance/rejection) to G3 Host
7. **Liquidity Update**: Update net debit cap position (increase available liquidity)
8. **Settlement Processing**: Include in settlement cycle processing
9. **Exception Handling**: Process CAMT.056 cancelation requests if received
10. **Reversal Processing**: Handle PACS.007 reversals and update liquidity accordingly

**7.4 Exception and Timeout Handling**

1. **Timer Monitoring**: Continuous SLA monitoring
2. **Timeout Detection**: Automatic detection of SLA breaches
3. **Exception Routing**: Failed transactions to exception queues
4. **Manual Intervention**: Operator interfaces for resolution
5. **Retry Mechanisms**: Configurable retry logic
6. **Escalation**: Automated escalation for critical issues

**8. Liquidity Management Implementation**

**8.1 Net Debit Cap Model**

* **Real-time Tracking**: Continuous balance calculation including DDI impact
* **Authorization Engine**: Pre-transaction liquidity checks for both outward payments and DDI
* **Threshold Alerts**: Configurable warning levels
* **Settlement Integration**: Twice-daily settlement cycle support
* **DDI Impact**: Direct debit transactions increase available liquidity (customer pays ANZ)

**8.2 Hold and Retry Mechanism**

* **Insufficient Funds**: Automatic payment holding for outward payments
* **DDI Authorization**: Real-time customer balance checking for direct debits
* **Retry Logic**: Configurable retry intervals and attempts
* **Queue Management**: Priority-based processing
* **Manual Override**: Operator intervention capabilities
* **Liquidity Impact**: Proper accounting for DDI vs outward payment liquidity effects

**9. Technology Stack and Infrastructure**

**9.1 Cloud Infrastructure (GCP)**

* **Kubernetes (GKE)**: Container orchestration
* **Service Mesh**: Inter-service communication
* **Load Balancing**: High availability and scaling
* **Auto-scaling**: Dynamic resource management

**9.2 Data Management**

* **Cloud Spanner**: Transactional consistency
* **~~BigQuery~~**~~: Analytics and reporting~~
* **Kafka**: Event streaming and messaging
* **~~Redis~~**~~: High-speed caching~~
* **Firestore**: For Audit and ADS data store

**9.3 Integration Patterns**

* **Event-driven Architecture**: Kafka-based pub/sub
* **API Gateway**: Secure API management
* **Circuit Breakers**: Resilience patterns
* **~~Saga Pattern~~**~~: Distributed transaction management~~

**10. Operational Excellence**

**10.1 Monitoring and Alerting**

* **Real-time Dashboards**: Transaction and system monitoring
* **Proactive Alerting**: Threshold-based notifications
* **Performance Analytics**: SLA and performance tracking
* **Capacity Planning**: Resource utilization monitoring

**10.2 User Interface Components**

* **Liquidity Management Console**: Real-time balance monitoring
* **Transaction Dashboard**: Payment flow visualization
* **Exception Management**: Manual intervention interface
* **Bank Status Management**: Participant availability tracking
* **Reporting Interface**: Business and operational reports

**11. Security and Compliance**

**11.1 Security Framework**

* **End-to-end Encryption**: HTTPS/MTLS throughout
* **~~Certificate Management~~**~~: Automated certificate lifecycle~~
* **Access Control**: Role-based access management
* **Audit Logging**: Comprehensive audit trails

**11.2 Regulatory Compliance**

* **MAS Compliance**: Singapore regulatory requirements
* **~~Data Residency~~**~~: Singapore data governance~~
* **Reporting**: Regulatory reporting automation
* **~~Risk Management~~**~~: Real-time risk monitoring~~

**12. Migration and Deployment Strategy**

**12.1 Phased Implementation**

* **Phase 1A**: Core gateway services deployment
* **Phase 1B**: Liquidity management integration
* **Phase 1C**: Operational UI and monitoring
* **Phase 1D**: Full production cutover

**12.2 Risk Mitigation**

* **Parallel Running**: Validation with existing systems
* **Gradual Cutover**: Phased traffic migration
* **Rollback Procedures**: Comprehensive rollback plans
* **24x7 Support**: Dedicated support during transition

**13. Success Metrics**

**13.1 Technical KPIs**

* **SLA Compliance**: 100% adherence to 4.5-second requirement for both CTI and DDI
* **System Availability**: 99.95% uptime target
* **Transaction Success Rate**: >99.9% success rate across all payment types
* **Processing Capacity**: Support for 20+ TPS with horizontal scaling (CTI, CTO, DDI combined)
* **DDI Processing**: Successful handling of direct debit authorization and settlement

**13.2 Business KPIs**

* **~~Operational Efficiency~~**~~: 50% reduction in manual interventions~~
* **Time to Market**: Accelerated new feature deployment
* **Cost Optimization**: Cloud-native cost efficiency
* **Regulatory Readiness**: 100% compliance with MAS requirements

This solution design leverages the comprehensive architecture shown in the diagram to deliver a robust, scalable, and compliant payment processing platform for Singapore's faster payment ecosystem.