

Technical Architecture: Manufacturing Execution & IIoT Platform (D365-MEB)

Executive Architecture Summary

Solution: Dynamics 365 Manufacturing Execution Bridge (D365-MEB)

Architecture Pattern: Cloud-native, microservices-based platform with edge computing capabilities

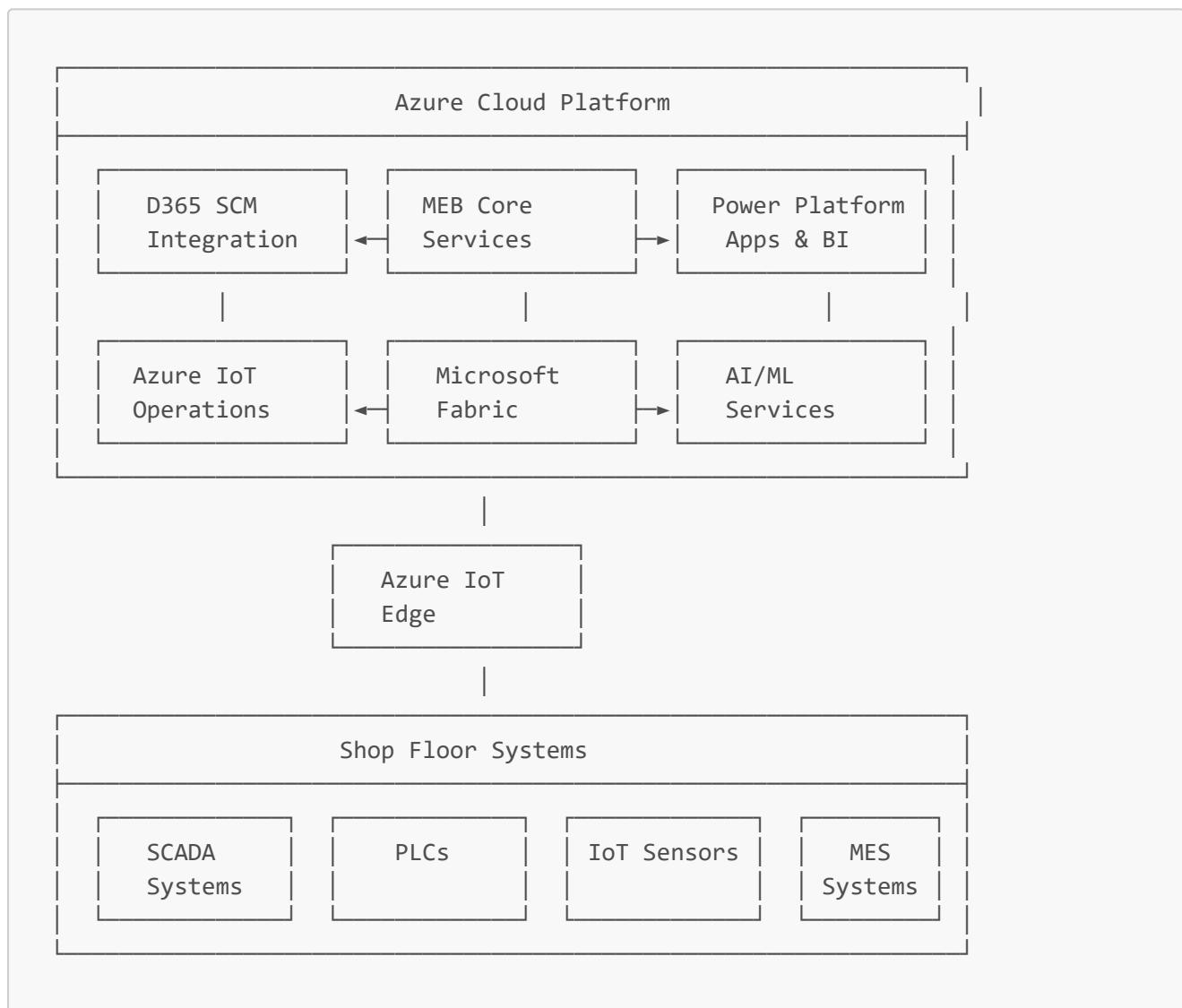
Primary Integration: Dynamics 365 Supply Chain Management + Azure IoT Operations

Target Scale: 1-1000+ manufacturing sites per tenant

Performance: ❤️ second response times, 10,000+ transactions/hour per site

System Architecture Overview

High-Level Architecture



Core Components Architecture

1. MEB Core Services (Azure Microservices)

Production Order Service

- **Technology:** Azure Container Apps with .NET 8
- **Responsibilities:** D365 SCM production order synchronization, work order management
- **APIs:** RESTful APIs with OpenAPI 3.0 specification
- **Performance:** <500ms response time, 1000+ concurrent requests
- **Data Storage:** Azure SQL Database with temporal tables for audit

Real-Time Data Ingestion Service

- **Technology:** Azure Event Hubs + Azure Stream Analytics
- **Responsibilities:** Shop floor data collection, sensor data processing
- **Protocols:** MQTT, OPC-UA, Modbus TCP, HTTP/REST
- **Throughput:** 100,000+ events per second per manufacturing site
- **Storage:** Azure Data Explorer for time-series data

Shop Floor Execution Service

- **Technology:** Azure Functions + SignalR for real-time communication
- **Responsibilities:** Work instruction delivery, progress tracking, quality recording
- **Integration:** Power Apps mobile client, web dashboards
- **Security:** Certificate-based device authentication, role-based access
- **Offline:** Local SQLite caching with sync capabilities

OEE Analytics Service

- **Technology:** Azure Machine Learning + Microsoft Fabric
- **Responsibilities:** Real-time OEE calculation, performance analytics
- **Algorithms:** Statistical process control, trend analysis, anomaly detection
- **Visualization:** Power BI embedded dashboards
- **Data Pipeline:** Near real-time with <30 second latency

2. Edge Computing Layer (Azure IoT Edge)

Edge Gateway Configuration

- **Hardware:** Industrial PC with Ubuntu 20.04 LTS
- **Runtime:** Azure IoT Edge runtime 1.4+
- **Local Processing:** Node.js modules for protocol translation
- **Storage:** Local time-series database (InfluxDB) for offline scenarios
- **Security:** TPM 2.0 hardware security module

Protocol Adapters

- **OPC-UA Client:** Connect to industrial automation systems
- **Modbus Gateway:** Support RTU and TCP variants
- **MQTT Broker:** Local MQTT broker for IoT device connectivity
- **Custom Connectors:** Extensible framework for proprietary protocols

3. Integration Architecture

Dynamics 365 Supply Chain Management Integration

- **Authentication:** Microsoft Entra ID with service principal
- **APIs:**
 - Production Orders API (GET, POST, PATCH)
 - Inventory Transactions API (POST)
 - Quality Orders API (GET, POST, PATCH)
 - Asset Management API (GET, POST)
- **Data Flow:** Real-time bidirectional synchronization
- **Error Handling:** Retry policies with exponential backoff
- **Rate Limiting:** Respect D365 API throttling limits

Power Platform Integration

- **Power Apps:** Canvas apps for mobile shop floor interfaces
- **Power BI:** Embedded analytics dashboards with row-level security
- **Power Automate:** Workflow automation for alerts and approvals
- **Dataverse:** Master data synchronization and offline capabilities

Microsoft Fabric Integration

- **Data Lakehouse:** Unified analytics platform for historical data
- **Real-Time Analytics:** KQL database for operational dashboards
- **Data Pipeline:** Medallion architecture (Bronze, Silver, Gold layers)
- **ML Models:** Automated ML for predictive maintenance and optimization

Data Architecture

Data Model Design

Core Entities

Production Order

```
CREATE TABLE ProductionOrders (
    ProductionOrderId NVARCHAR(50) PRIMARY KEY,
    D365ProductionOrderId NVARCHAR(50) NOT NULL,
    ItemNumber NVARCHAR(50) NOT NULL,
    Quantity DECIMAL(18,4) NOT NULL,
    ScheduledStartDate DATETIME2 NOT NULL,
    ScheduledEndDate DATETIME2 NOT NULL,
    Status NVARCHAR(20) NOT NULL,
    WorkCenterId NVARCHAR(50) NOT NULL,
    RouteId NVARCHAR(50),
    CreatedDateTime DATETIME2 DEFAULT GETUTCDATE(),
    ModifiedDateTime DATETIME2 DEFAULT GETUTCDATE(),
    SyncStatus NVARCHAR(20) DEFAULT 'Pending'
);
```

Machine Data

```
CREATE TABLE MachineData (
    MachineDataId BIGINT IDENTITY(1,1) PRIMARY KEY,
    MachineId NVARCHAR(50) NOT NULL,
    Timestamp DATETIME2 NOT NULL,
    DataType NVARCHAR(50) NOT NULL,
    Value FLOAT NOT NULL,
    Unit NVARCHAR(20),
    Quality NVARCHAR(20) DEFAULT 'Good',
    ProductionOrderId NVARCHAR(50),
    INDEX IX_MachineData_Timestamp CLUSTERED (Timestamp),
    INDEX IX_MachineData_Machine (MachineId, Timestamp)
);
```

OEE Metrics

```
CREATE TABLE OEEMetrics (
    OEEMetricId BIGINT IDENTITY(1,1) PRIMARY KEY,
    WorkCenterId NVARCHAR(50) NOT NULL,
    ProductionOrderId NVARCHAR(50),
    PeriodStartTime DATETIME2 NOT NULL,
    PeriodEndTime DATETIME2 NOT NULL,
    PlannedProductionTime DECIMAL(10,2) NOT NULL,
    ActualProductionTime DECIMAL(10,2) NOT NULL,
    DowntimeMinutes DECIMAL(10,2) NOT NULL,
    IdealCycleTime DECIMAL(10,4) NOT NULL,
    TotalPieces INT NOT NULL,
    GoodPieces INT NOT NULL,
    Availability DECIMAL(5,4) NOT NULL,
    Performance DECIMAL(5,4) NOT NULL,
    Quality DECIMAL(5,4) NOT NULL,
    OEE DECIMAL(5,4) NOT NULL,
    CalculatedDateTime DATETIME2 DEFAULT GETUTCDATE()
);
```

Data Flow Architecture

Real-Time Data Pipeline

1. Data Ingestion

- Shop floor systems → Azure IoT Edge → Azure IoT Hub
- Event processing: Azure Event Hubs → Azure Stream Analytics
- Data storage: Azure Data Explorer (hot path), Azure SQL (warm path)

2. Data Processing

- Stream processing: Complex Event Processing for real-time alerts
- Batch processing: Azure Data Factory for historical analytics
- ML processing: Azure Machine Learning for predictive models

3. Data Consumption

- Real-time dashboards: SignalR → Power BI → Web clients
- Mobile apps: Power Apps → Dataverse → Azure SQL
- API consumers: Azure API Management → Microservices

Security Architecture

Authentication and Authorization

Microsoft Entra ID Integration

- **Primary Authentication:** Azure AD B2B for enterprise users
- **Device Authentication:** Certificate-based for IoT devices
- **API Authentication:** OAuth 2.0 with JWT tokens
- **Role-Based Access Control:** Custom roles aligned with D365 security

Security Roles Definition

```
{
  "roles": [
    {
      "name": "ProductionOperator",
      "permissions": ["ReadWorkOrders", "UpdateProgress", "RecordQuality"],
      "scope": "WorkCenter"
    },
    {
      "name": "ProductionSupervisor",
      "permissions": ["ReadAllWorkOrders", "ManageSchedules", "ViewOEE"],
      "scope": "Plant"
    },
    {
      "name": "PlantManager",
      "permissions": ["ViewAllReports", "ManageUsers", "ConfigureSystem"],
      "scope": "Enterprise"
    }
  ]
}
```

Data Security

Encryption Standards

- **Data in Transit:** TLS 1.3 for all API communications
- **Data at Rest:** AES-256 encryption for Azure SQL and Storage

- **Key Management:** Azure Key Vault with managed HSM
- **Certificate Management:** Automated certificate rotation

Compliance Framework

- **SOC 2 Type II:** Security, availability, processing integrity
- **ISO 27001:** Information security management
- **GDPR:** Personal data protection for EU operations
- **Industry Standards:** ISA-95, NIST Cybersecurity Framework

Performance and Scalability

Performance Specifications

Response Time Requirements

- **Real-time dashboards:** ❤️ seconds for data refresh
- **Mobile app interactions:** <1 second for common operations
- **API responses:** <500ms for critical production operations
- **Report generation:** <10 seconds for standard OEE reports

Throughput Requirements

- **Data ingestion:** 100,000+ sensor readings per minute per site
- **Transaction processing:** 10,000+ production transactions per hour
- **Concurrent users:** 500+ simultaneous users per manufacturing site
- **API calls:** 10,000+ API calls per minute with burst capacity

Scalability Architecture

Horizontal Scaling Strategy

- **Microservices:** Auto-scaling Azure Container Apps
- **Database:** Azure SQL elastic pools with read replicas
- **Caching:** Azure Redis Cache with clustering
- **CDN:** Azure Front Door for global content delivery

Multi-Tenant Architecture

```
{
  "tenancy_model": "shared_database_separate_schema",
  "tenant_isolation": {
    "data": "Row-level security with tenant_id",
    "compute": "Shared with resource limits",
    "customization": "Tenant-specific configuration"
  },
  "scaling_metrics": {
    "tenant_count": "10,000+ tenants",
    "sites_per_tenant": "1-1000 sites",
    "users_per_tenant": "10-10,000 users"
  }
}
```

```
}
```

Implementation Plan

Phase 1: Foundation Infrastructure (Months 1-4)

Development Team Requirements

- **Solution Architect:** 1 FTE (Azure, D365, manufacturing expertise)
- **Backend Developers:** 3 FTE (.NET, Azure, microservices)
- **Frontend Developers:** 2 FTE (React, Power Platform)
- **DevOps Engineer:** 1 FTE (Azure, Kubernetes, CI/CD)
- **IoT Specialist:** 1 FTE (Edge computing, industrial protocols)

Key Deliverables

- Azure infrastructure setup with multi-tenant architecture
- Core microservices (Production Order, Data Ingestion)
- Basic D365 SCM integration with production orders
- IoT Edge gateway with OPC-UA connectivity
- Power Apps mobile application for operators

Success Criteria

- 5 pilot customers processing production orders through MEB
- Real-time data collection from 10+ machines per site
- Basic OEE calculation and visualization
- ❤️ second response times for dashboard updates

Phase 2: Advanced Analytics (Months 5-8)

Additional Team Requirements

- **Data Scientist:** 1 FTE (ML, predictive analytics)
- **Power BI Developer:** 1 FTE (embedded analytics, custom visuals)

Key Deliverables

- Advanced OEE analytics with root cause analysis
- Predictive maintenance algorithms and alerts
- Power BI embedded dashboards with drill-down capabilities
- Quality management integration with D365
- Performance optimization and scalability improvements

Success Criteria

- 25+ customer deployments with documented ROI
- Predictive maintenance reducing downtime by 20%

- Advanced analytics providing actionable insights
- Customer satisfaction >85% Net Promoter Score

Phase 3: Enterprise Scale (Months 9-12)

Key Deliverables

- Multi-site deployment and management capabilities
- Advanced security and compliance features
- Partner ecosystem and marketplace presence
- Industry-specific configurations and templates
- Global deployment with regional data residency

Success Criteria

- 75+ customer deployments across multiple industries
- Multi-site customers with >5 manufacturing locations
- Microsoft AppSource marketplace listing with reviews
- Partner channel generating 50% of new sales

Risk Assessment and Mitigation

Technical Risks

Integration Complexity (High Impact, Medium Probability)

- **Risk:** Complex D365 API integration affecting reliability
- **Mitigation:** Microsoft partnership, extensive testing, fallback mechanisms
- **Timeline Impact:** +2 months for comprehensive integration testing

Performance at Scale (Medium Impact, Medium Probability)

- **Risk:** System performance degradation with large deployments
- **Mitigation:** Load testing, auto-scaling, performance monitoring
- **Investment:** \$200K additional cloud infrastructure for testing

IoT Device Connectivity (Medium Impact, High Probability)

- **Risk:** Industrial network connectivity and protocol compatibility
- **Mitigation:** Multiple protocol support, edge caching, offline capabilities
- **Resource:** Additional IoT specialist for 6 months

Business Risks

Market Competition (High Impact, Medium Probability)

- **Risk:** Microsoft or competitors launching similar native functionality
- **Mitigation:** Deep customer relationships, continuous innovation
- **Strategy:** Focus on industry specialization and superior user experience

Customer Adoption (Medium Impact, Low Probability)

- **Risk:** Manufacturing customers hesitant to adopt cloud-based solutions
- **Mitigation:** Strong ROI demonstration, hybrid deployment options
- **Investment:** Additional customer success resources

Resource Requirements Summary

Development Team (24 months)

- **Total FTEs:** 10-12 team members
- **Estimated Cost:** \$3.2M in development resources
- **Key Skills:** Azure architecture, D365 integration, IoT, manufacturing

Infrastructure Investment

- **Azure Services:** \$150K/year for development and testing
- **Production Infrastructure:** Auto-scaling based on customer usage
- **Monitoring and Security:** \$50K/year for comprehensive observability

Go-to-Market Investment

- **Microsoft Partnership:** ISV partner program participation
- **Sales and Marketing:** \$500K for customer acquisition
- **Customer Success:** \$300K for implementation support

Total Initial Investment: \$4.2M over 24 months

Break-even: Month 18 with 25+ customer deployments

ROI: 350% by month 36 with target customer base

Conclusion

The Manufacturing Execution & IIoT Platform represents a comprehensive technical solution that addresses the critical gap between D365 Supply Chain Management and shop floor operations. The cloud-native, microservices architecture with edge computing capabilities provides the scalability, performance, and reliability required for enterprise manufacturing environments.

The phased implementation approach enables rapid market entry while building toward full-scale enterprise deployment. Strong Microsoft ecosystem integration and adherence to industry standards position this solution for sustainable competitive advantage in the growing D365 manufacturing market.