Substation Modernization

2012 Automation Webinar Series

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Power System Engineering, Inc.
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1 Starting Points
2 Why Modernize?
3 Phased Approach
4 Communication & Security
5 Next Steps
# Starting Points

Utilities are coming from many different perspectives – No one right answer.

<table>
<thead>
<tr>
<th>Category</th>
<th>States</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sizes</td>
<td><strong>Meters</strong>: 5,000 to 100,000+</td>
<td>Cost justification varies.</td>
</tr>
<tr>
<td></td>
<td><strong>Substations</strong>: 5 to 200+</td>
<td>Complexity increases with size.</td>
</tr>
<tr>
<td>Structure</td>
<td>Cooperative, Municipal, G&amp;T</td>
<td>Different process for justifying expenditure &amp; investment.</td>
</tr>
<tr>
<td></td>
<td>Investor-owned Utility</td>
<td></td>
</tr>
<tr>
<td>Territory</td>
<td><strong>Rural</strong> with locations spread</td>
<td>Impacts some of the benefits of automation.</td>
</tr>
<tr>
<td></td>
<td>widely</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Urban</strong> with compact service</td>
<td></td>
</tr>
<tr>
<td></td>
<td>territory</td>
<td></td>
</tr>
<tr>
<td>Services</td>
<td>Municipals add gas and water systems to any automation plan.</td>
<td></td>
</tr>
<tr>
<td>Focus</td>
<td>Reliability</td>
<td>Need to make sure benefits accomplish your goals.</td>
</tr>
<tr>
<td></td>
<td>Reduced Cost of Service</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Personnel stretched thin</td>
<td></td>
</tr>
</tbody>
</table>
Starting Point – Automation Hybrid

SCADA Master
- Central Server
- Central Workstation
- Legacy Server Hardware
- Proprietary Database
- Leased-line modems

Substation Automation
- Legacy RTU – serial proprietary protocol
- New feeder relays
- Regulator control – 10 years old, communicates for proprietary protocol
- Substation also contains a Load Management or AMI interface unit
Role of the RTU

Legacy
- **Capture signals** (analog & digital) from transducers.
- **Data gathering** without decision making.
- **Vendor specific** protocols
- Gather data from serial devices.
- **Constrained** by limited communications.
- **Limited history**, sequence of events.

Modern
- **One of many intelligent devices.**
- **Data gathering** blended with decision making.
- **Standard (DNP3, 61850) protocols.**
- Gather data from legacy transducers & devices.
- **Enabled** by improved communications.
- **Greater history**, sequence of events.
# Starting Point – Multi-generation IEDs

Faced with decision on whether to invest in newer IEDs

<table>
<thead>
<tr>
<th>Status</th>
<th>Generation 1</th>
<th>Generation 2</th>
<th>Generation 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Obsolete</td>
<td>Supported</td>
<td>Newest platform</td>
</tr>
<tr>
<td>Protocols</td>
<td>Proprietary serial</td>
<td>DNP3 Serial &amp; IP</td>
<td>DNP3 Serial &amp; IP</td>
</tr>
<tr>
<td>Settings</td>
<td>Select pre-defined Time-current curves</td>
<td>User customized logic, Time-current curve editing</td>
<td>Advanced editing of Time-current curves</td>
</tr>
<tr>
<td>Metering</td>
<td>Current in 5 or 15 minute integrals.</td>
<td>I&amp;V, power, energy, PF, Frequency, harmonic</td>
<td>I&amp;V, power, energy, PF, Frequency, harmonic</td>
</tr>
<tr>
<td>Load Profiling</td>
<td>Currents for last 24hr. in 15 min. intervals</td>
<td>Configurable data and many intervals, days of info.</td>
<td>Configurable data and many intervals, days of info.</td>
</tr>
<tr>
<td>Event Recorder</td>
<td>Current for last 25 events</td>
<td>Many event types, Last 500 events</td>
<td>Many event types, Last 500 events</td>
</tr>
<tr>
<td>Oscillography</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>General</td>
<td>Functional, yet … No longer supported Proprietary Basic Configurability Limited information</td>
<td>Functional Well supported Standards-based Flexible Lots of information</td>
<td></td>
</tr>
</tbody>
</table>
Starting Point – Standards & Protocols

Standards Based
• DNP3.0
• IEC-61850
• Modbus TCP

Proprietary
• Valmet Tejas
• Telegyr 8979
• PG&E 2179

Why does the protocol matter?

– Manufacturer Flexibility
  • Support from the manufacturer, staying in business
  • Breadth of product types and features

– Improvements in protocol
  • Communication types (Ethernet, report by exception, …)
  • Security
1 Starting Points
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3 Phased Approach
4 Communication & Security
5 Next Steps
Modern SCADA Architecture

- Intelligent devices remotely accessible
- Bi-directional data flow
- High level of redundancy

Fiber Backbone

Substation

SCADA Master

Workstation

Redundant Master

DA/AMI Collection Point

Intelligent devices remotely accessible makes sense as part of a bigger picture.
Modern SCADA Masters

SCADA System Components

- **Software:** License (features) and maintenance
- **Hardware:** Servers, workstations, network, security
- **Engineering:** Database and screen design, site testing
- **Training:** User, upgrade and modification

Representative Cost Break-down

Features to consider:

- Redundant modular hardware
- Firewalls for secure remote access
- Open database for 3rd party integration
- Historian, trending and graphing
- Tagging for secure lockout
- User authentication for access levels
- Web access for infrequent users
- ICCP, MultiSpeak & protocol interfaces
- Security logging for NERC CIP
- Advanced applications
Getting more out of Automation

• Extend Asset Life
  – Transformer upgrades or added substations are expensive
  – Actual peak loading provides the best picture on upgrading

• Enable Restoration
  – Temporarily run closer to maximum only with real-time data

• Update engineering models
  – Assumption: residential vs. industrial vs. commercial load mix
  – Measure power factor variance with time, day and season
  – Measure energy change with voltage reduction

• Better feeder loading data
  – Measure individual feeder loading rather than whole bus
  – Measure feeder power factor for better compensation

Better technical information allows better business decisions.
## SCADA Benefits Many

<table>
<thead>
<tr>
<th>Function</th>
<th>Legacy Systems</th>
<th>Modern SCADA</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Customer Service</strong></td>
<td>• Customer reported issues</td>
<td>• Continuous monitoring</td>
<td>• Better customer service</td>
</tr>
<tr>
<td></td>
<td>• Continuous monitoring</td>
<td>• Detect before call</td>
<td></td>
</tr>
<tr>
<td><strong>Operations &amp; Dispatch</strong></td>
<td>• Drive through affected area to suspected source</td>
<td>• Field data on location of fault</td>
<td>• More quickly locate source of outage</td>
</tr>
<tr>
<td></td>
<td>• Drive through affected area to suspected source</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Maintenance</strong></td>
<td>• Travel to every site</td>
<td>• Gather remotely</td>
<td>• Less drive time</td>
</tr>
<tr>
<td></td>
<td>• No info between visits</td>
<td>• Travel when needed</td>
<td>• More information</td>
</tr>
<tr>
<td></td>
<td>• Travel to every site</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>System Engineering</strong></td>
<td>• Limited system data</td>
<td>• Real-time historical information and settings.</td>
<td>• Verify system models with actual load data</td>
</tr>
<tr>
<td></td>
<td>• Tough to gather data</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Field Engineers</strong></td>
<td>• Meters provide some data within substation.</td>
<td>• Substation HMI shows complete picture</td>
<td>• See system status and control system from field</td>
</tr>
<tr>
<td></td>
<td>• Meters provide some data within substation.</td>
<td>• Local control</td>
<td></td>
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</table>

Information helps all departments work more efficiently.
Maintaining your system

• Many utilities can no longer maintain their system
  – Proprietary implementations: can’t update themselves
  – RTUs & SCADA Masters no longer supported

• Newer SCADA systems are easier to maintain
  – Friendlier graphical interfaces, easier screen creation
  – Templates for common IEDs
  – Easier to add communication channels
  – Alarm management standardly supported
  – Many trends and graphs are built-in or easily modified

If your system can’t grow, your investment has limited value long-term.
Benefits of Standard Protocols – DNP3

• DNP3 Attributes
  – **Open** definition: everyone can implement, interoperate
  – **Flexible**: Binary, analog, counters, data files
  – **Reliable**: Error checking & retransmission built in
  – Support all **media**: Serial & Ethernet / Fiber capable
  – **Prioritized**:
    • Static data & Class 1, 2, & 3 event data
    • Polled & Unsolicited Messaging
  – **Time Stamped**: Recreate events
  – **Security** Enhancements: DNP3 Secure Authentication

Allows vendor independence, enhancements and operational benefit.
Voltage Control Program

Substation Automation forms basis for voltage control

- **Benefits**
  - Coincident peak price reduction
  - Energy Reduction

- **Components of a voltage control program**
  - Regulation (Substation and Feeder)
  - Measurement (Meters and Regulators)
  - Control (SCADA or Integrated Volt/VAR Application)

- **Considerations**
  - Seasonal / Daily Load
  - Metering latency
  - Dynamic network
Switching Program

Substation Automation forms basis for switching

• Benefits
  – Increased Reliability (reduced SAIDI)

• Implementation Options
  – Central / Distributed Control
  – Central visibility in real time

• Complexities
  – Maintaining communications
  – Restore to normal state after repair
  – Modeling a dynamic load
  – Switching voltage control
Modernization Benefits

1. **Integration**: SCADA System pulls together many pieces for greater benefit.

2. **Fiscal**: Better information allows better business decisions.

3. **Operational**: Access to information helps all departments.

4. **Maintainability**: Use and expand system

5. **Standards**: Protocols
   a) Vendor independence.
   b) Evolve to improve security and operational benefits.

6. **Platform**: Voltage control and switching programs allow for cost reduction and reliability increases.
Agenda

1  Starting Points
2  Why Modernize?
3  Phased Approach
4  Communication & Security
5  Next Steps
# Levels of Automation

<table>
<thead>
<tr>
<th>Component</th>
<th>Basic</th>
<th>Median</th>
<th>Advanced</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCADA Master</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Hardware</td>
<td>Single PC</td>
<td>Single Rack Server</td>
<td>Redundant Rack Servers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Single PC Workstation</td>
<td>Multiple PC Workstations</td>
</tr>
<tr>
<td>Applications</td>
<td>Monitoring</td>
<td>Control, Alarm Mgmt., Historian &amp; Trending</td>
<td>Control, Alarm, Historian, Switching, IVVC,</td>
</tr>
<tr>
<td></td>
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<td></td>
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<tr>
<td>Substation Automation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RTU/Controller</td>
<td>RTU to I/O</td>
<td>Data Concentrator</td>
<td>Minimal – IED direct</td>
</tr>
<tr>
<td>Feeder Protection</td>
<td>Hydraulic</td>
<td>IED Relays</td>
<td>IED Relays</td>
</tr>
<tr>
<td>Feeder Capacitors</td>
<td></td>
<td>Fixed</td>
<td>IED Controller</td>
</tr>
<tr>
<td>Regulation</td>
<td></td>
<td>IED Bus Control or LTC</td>
<td>IED Feeder Controller</td>
</tr>
<tr>
<td>Transformer</td>
<td>Unmonitored</td>
<td>I/O Alarms</td>
<td>IED Monitor</td>
</tr>
<tr>
<td>High Side Protection</td>
<td></td>
<td>IED Relays</td>
<td>IED Relays</td>
</tr>
<tr>
<td>Substation Support</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substation SCADA</td>
<td></td>
<td>HMI – Local Devices</td>
<td>Full Workstation</td>
</tr>
<tr>
<td>Video</td>
<td></td>
<td></td>
<td>IP Camera</td>
</tr>
<tr>
<td>Local Network</td>
<td></td>
<td></td>
<td>IP Phone, Wireless LAN</td>
</tr>
</tbody>
</table>
Phased Approach

• Every utility has valuable assets
  – **IEDs**: Relays, regulator controls, meters.
  – **Communications**:
    • **Fiber (Partial) Deployment**: Municipalities with community fiber programs
    • **Wireless assets**: Including towers
  – **Other Systems**: that can be integrated with SCADA
    • Automated Metering (AMI/AMR)
    • Outage Management System (OMS)
    • Geographic Information System (GIS)

Maximize the benefit of what you have toward the programs you need.
Substation SCADA – SCADA Lite

- Substation communication processor hosts SCADA directly.
- Lower cost of equipment and deployment.
- Visibility to what’s going on locally
- Limited scalability and integration with other applications: AMI, CVR, OMS.
- Local substation control, limited system-wide control.

Local visibility at low cost and complexity.
Data Concentrators & RTUs

• **Trends**
  - Legacy protocols going to DNP3
  - Serial going to Ethernet
  - Heavily I/O monitoring going to IEDs
  - Data concentrators used frequently
  - Increased intelligence, HMI capability
  - PLCs are increasingly finding use.

• **Features of modern platforms**
  - Intelligence – logic and decision making
  - Great at integrating diverse protocols.
  - HMI in some instances (pseudo-SCADA)
  - Security embedded – firewalls, etc.
Substation Migration Example: Starting

**SCADA Master**
- Central Server
- Central Workstation
- Legacy Server Hardware
- Proprietary Database
- Leased-line modems

**Substation Automation**
- Legacy RTU – serial proprietary protocol
- New feeder relays
- Regulator control – 10 years old, communicates for proprietary protocol
- Substation also contains a Load Management or AMI interface unit
Substation Migration Example: Long-Term

SCADA Master
- Powerful server & workstation(s)
- Monitoring & alarming
- Substation & DA control
- Historian & trending
- OMS/AMI integration

Substation Automation
- Maximize direct connection to IEDs w/ DNP3 over IP
- IED Reclosers
- Minimized RTU
- IED Regulators
- AMI & DA collector point
- Fiber Ethernet in substation
Substation Migration Example: Phase 1

**SCADA Master**
- Powerful server & workstation
- Monitoring & alarming
- Substation & DA control
- Historian & trending
- OMS/AMI integration

**Substation Automation**
- Maximize direct connection to IEDs w/ DNP3 over IP
- IED Reclosers
- Minimized RTU
- IED Regulators
- AMI & DA collector point
- Fiber Ethernet in substation
Phased Approach

How we develop the phasing strategy depends on what is most valuable to the utility.

1. **Level**: Automation goal depends on size & programs.
2. **Current assets**: Make the most of what you have.
3. **SCADA Lite**: Consider substation level SCADA.
4. **RTU**: Balance data concentration & RTU role in short-term & long-term
5. **Phasing**: Prioritize the assets with most critical goals.
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## Multi-Tier Infrastructure

<table>
<thead>
<tr>
<th>Tier</th>
<th>Description</th>
<th>Speed</th>
<th>Coverage</th>
<th>Redundancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Backbone Connect offices and most substations</td>
<td>High speed 10-100+ Mbps</td>
<td>Ring</td>
<td>Critical</td>
</tr>
<tr>
<td>2</td>
<td>Backbone Extension Connects remote substations</td>
<td>Medium speed 10+ Mbps</td>
<td>Pt. – Pt.</td>
<td>Preferable</td>
</tr>
<tr>
<td>3</td>
<td>DA Network Connect field DA equipment to each other and to a collection point to the SCADA system.</td>
<td>Lower speed 50 kbps to 1 Mbps</td>
<td>Wide-area</td>
<td>Preferable</td>
</tr>
<tr>
<td>4</td>
<td>AMI Network Connect meters to each other and to a collection point.</td>
<td>Lower speed &lt;50 kbps to 1 Mbps</td>
<td>Wide-area</td>
<td>Preferable</td>
</tr>
</tbody>
</table>

![Diagram of Multi-Tier Infrastructure](image-url)
## Bandwidth Requirements

<table>
<thead>
<tr>
<th>Application</th>
<th>Use Case</th>
<th>Frequency of Use</th>
<th>Latency Target (Sec)</th>
<th>Message Size (bits)</th>
<th>Number of Devices</th>
<th>Throughput (kbps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMI</td>
<td>Interval data read</td>
<td>Hourly interval data read 3x per day</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Outage Notification &amp; Restoration</td>
<td>Primarily major outages.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Demand Side Management / Load Control</td>
<td>During load control events</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCADA</td>
<td>IED Monitoring &amp; Control</td>
<td>Every 2 seconds</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineering</td>
<td>Data needed by direct connect to IEDs</td>
<td>1 x per week</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Video Monitoring</td>
<td>Security - sending frames on event</td>
<td>Infrequent</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Distribution Automation</td>
<td>Assumed unsolicited report by exception based on events</td>
<td>Hourly</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Wi-Fi</td>
<td>Substation hotspots for field crew network access</td>
<td>A few times per day</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td><strong>Total</strong></td>
<td></td>
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</tr>
</tbody>
</table>
Electric Critical Infrastructure Program

- NERC is responsible for Energy Sector, Electric Segment
- NERC Critical Infrastructure Protection (CIP)
  - Efficiently identify security threats and vulnerabilities
  - Develop policies and procedures to address these threats and vulnerabilities
  - Bolster training and education activities for owners and operators
- Currently focused on “Bulk Electric System”

<table>
<thead>
<tr>
<th>Version</th>
<th>Status</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Effective Oct. 2010</td>
<td>Allowed utilities to define CAs by a risk-based assessment</td>
</tr>
<tr>
<td>4</td>
<td>Approved by NERC Q1 2011; Awaiting FERC approval – latest comment 11/21/2011</td>
<td>Change the way Critical Assets are identified to greatly expand the number of Bulk Electric System assets (generation plants, transmission substations, etc.)</td>
</tr>
<tr>
<td>5</td>
<td>FERC required NERC submit by Q3 2012</td>
<td>Complete coverage of FERC Order 706 Critical Assets -&gt; Bulk Electric System Cyber Assets Classifications for control centers, generation plants &amp; transmission substations</td>
</tr>
</tbody>
</table>
Components of Security

• Encryption
  – Scrambling data so that it is unreadable to those who aren’t supposed to read it.

• Authentication
  – Verifying that the devices who want to talk to each other are allowed.

• Integrity Checking
  – Verifying that messages are not changed from sender to receiver.

• Intrusion Detection
  – Detecting if someone or something is trying to break any of the security aspects above.
  – Failed authentication – wrong password
  – Denial of service, replay attack, changed messages
DNP3 Secure Authentication Version 5

• Addressing the Issue: Securing remote devices

• Authentication: Verify correct User & Outstation
  – Addresses: Spoofing, Modification, Replay
  – Does not address: Eavesdropping & Encryption

• Unauthenticated / authenticated messages (MAC)
  – Control operations critical

• Backward tolerant & upgradable

• Multiple users & auditing (audit trail beyond standard)
Security Scalability

- Essential: Switch and fiber/microwave
- Recommended: Firewall and encryption
- NERC CIP required: MPLS tunnel

Switch
Firewall
Encryption
MPLS Tunnel
Fiber/Microwave

Connectivity
Inspection and intrusion prevention
Data obscurity and integrity checking
Non-routable (sub to control center only)
Physical connection
Agenda

1 Starting Points
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Present State

- Current Programs and Assets
- Identify Business Goals
- What are Industry Trends?
- Available Staff Resources
- Current Limitations

Desired State

- Future Automation Programs
- Distribution Automation?
- Smarter Database: MDM?
- Uncover other Programs

Gap Analysis

Identify High Value Programs

Transition Plan

Automation Roadmap – AMI, DA, SCADA, MWM, AVL, Others

Communications Roadmap

Implementation

Technology Goals Accomplished!
<table>
<thead>
<tr>
<th>Programs</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AMI &amp; Beyond</strong></td>
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<tr>
<td>Procurement/Design</td>
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<tr>
<td>Software/Hardware/Vendor</td>
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<tr>
<td>installation</td>
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<tr>
<td><strong>Substation Modernization</strong></td>
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<tr>
<td>Equipment</td>
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<tr>
<td><strong>GIS</strong></td>
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<tr>
<td>installation</td>
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<td><strong>MWM</strong></td>
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Modernization Overview

1. **Starting Point:** Hybrid systems, each in unique size and make-up.

2. **Benefits:**
   - Fiscal & operational benefits of improved information.
   - Foundation for voltage & switching programs

3. **Phased Approach:** Incrementally build on existing assets to maximize key programs.

4. **Communications:** Enable secure remote data access

5. **Creating a plan:** Identify the gap & create a plan that balances dollars and resources for all programs.
Questions?

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