

**Title:** Knowledge Graphs - Data in Context for Responsive Businesses

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**Date:** July, 2021

## **Introduction**

Knowledge graphs represent entities and their relationships in both human and machine-readable formats to enable reasoning and knowledge discovery by using organizing principles.

## **Key Findings**

- Knowledge graphs impose structure and semantics on data through organizing principles like taxonomies and ontologies. This makes data "smarter".
- Actioning knowledge graphs focus on driving decisions by integrating, contextualizing, and governing data from across silos. Popular use cases include customer 360, data catalogs, and supply chain optimization.
- Decisioning knowledge graphs apply analytics like algorithms and machine learning to extract insights from graph data. This improves predictions and recommendations.
- Knowledge graphs provide the diverse, contextualized data needed for transparent and accurate AI systems. They also enable transfer learning and explainability.
- Digital twins powered by real-time data use knowledge graphs and AI to create virtual models of systems and processes for monitoring, simulation, prediction, and optimization.

## **Limitations**

- Knowledge graphs require iterative development and should start by solving high-priority use cases with "just enough" semantics to prove value.
- Adoption requires changes in processes and mindsets to leverage connected, contextualized data.

## **Recommendations**

- Start small by incrementally adding structure and semantics to key datasets to address pressing needs.
- Focus initial projects on high-impact challenges like customer 360, data governance, or supply chain resilience.
- Leverage graph analytics and visualizations to uncover insights before incorporating machine learning.

- Reuse existing standards like SKOS, schema.org, and OWL where possible.

## **Conclusion**

- Knowledge graphs make data more useful and actionable by connecting it and adding organizational context.
- They power a variety of applications from analytics to AI by revealing contextual insights and patterns.

## **Future Aspects**

- Knowledge graphs will be increasingly combined with AI approaches like graph neural networks for sophisticated predictions and decisions.
- Adoption will accelerate as businesses seek to leverage connected data and need transparency for AI systems.

In summary, this report provides a comprehensive overview of knowledge graphs and demonstrates their ability to drive business value by making data smarter and more connected. It offers practical guidance for incrementally adopting knowledge graphs.

**Incorporating a knowledge graph into a labor market information system might be able to provide several key advantages:**

### Data Integration

A knowledge graph would enable integrating disparate labor market data sources into a unified, interconnected data model. This includes linking information on job postings, skills, salaries, education programs, and more. The relationships in the graph provide critical context.

### Improved Recommendations

With an integrated knowledge graph, the system can make better recommendations for careers, education paths, and job opportunities by leveraging contextual information like related skills and qualifications. More relevant results improve user experiences.

### Knowledge Discovery

A knowledge graph opens up new opportunities for knowledge discovery using techniques like graph algorithms, embeddings, and visualizations. This can uncover non-obvious insights like skill clusters and regional hiring trends.

### Explainable AI

Machine learning models for things like job recommendation and skills forecasting can be made more accurate, transparent, and adaptable by incorporating knowledge graph data for context and provenance tracking.

**To realize these benefits, the knowledge graph should include:**

- Entities like job postings, skills, qualifications, educations, employers
- Relationships between entities like REQUIRES, OFFERS, LOCATED\_IN
- Taxonomies for standardized occupational categories and skills
- Metadata like job posting date, salary, source, etc.
- Links to relevant external knowledge bases (ex. Census Data, LinkedIn Skills Database, Company Websites, Industry Association Resources)

**Some examples of government agencies that have implemented knowledge graphs for labor market and workforce applications:**

1. WorkforceGPS (USA)

- Developed by The U.S. Department of Labor's Employment and Training Administration (ETA) to connect information and resources on workforce development
- Created to help build the capacity of America's public workforce investment system
- Features virtual training events
- Uses knowledge graph to link occupations, skills, credentials, training content, funding sources etc.
- Enables personalized recommendations for career planning and talent development

2. MySkillsFuture (Singapore)

- National skills ecosystem in Singapore led by Ministry of Education that aims to help individuals, businesses, and the government to upskill, reskill, and learn new skills for the future
- Comprehensive portal offering details on courses, training, and apprenticeships, along with financial assistance for training
- Incorporates a knowledge graph, a centralized information hub about skills, courses, and training
- Allows users to explore career pathways and identify skills gaps

3. JobTech (Sweden)

- Swedish company that develops AI-powered recruitment solutions
- Government initiative to make labor market data open and accessible
- APIs and knowledge graph model available for developers and researchers
- Used to power apps for matching job seekers to vacancies
- Allows them to match job seekers with jobs based on their skills, experience, and interests
- use of knowledge graphs is helping them to improve the accuracy, efficiency, and personalization of the recruitment process

#### 4. CareerExplorer by FutureFit AI (Canada)

- developed by FutureFit AI, an artificial intelligence company, with funding from the Government of Canada's Future Skills Program
- Aims to help youth and mid-career professionals navigate career transitions
- Interactive tool for exploring career options based on interests, skills, qualifications
- AI and knowledge graphs to connect occupations, demanded skills, education programs, training options, and more
- The knowledge graph contains over 10,000 concepts and millions of connection points between occupations, skills, education pathways and work activities
- Enables semantic search, recommendations and analytics to provide personalized career insights

These demonstrate the applicability of knowledge graphs in enhancing labor/workforce data and empowering users with personalized insights and guidance. With thoughtful design focused on local needs, a Knowledge Graph could similarly benefit the Ministry's services.

**Incorporating a Knowledge Graph into a Ministry-led Labor Market Information System (LMIS) could have the following anticipated benefits and effects:**

#### Career Guidance

- Connect occupations, skills, qualifications, training programs, and career pathways
- Provide personalized career recommendations based on citizen's profile and preferences
- Empower citizens to explore options and make informed career decisions

### Skills Anticipation

- Model relationships between jobs, skills, credentials, emerging technologies
- Gain insights into future skills demands and labor market shifts
- Inform policymaking and guide skills development programs

### Training Program Management

- Align training programs to required skills and qualifications for occupations
- Identify skills gaps in existing programs, optimize course content
- Streamline program discovery and enrollment for citizens

### Job Matching and Placement

- Match citizen skills and preferences to suitable job vacancies and recommendations
- Provide semantic search and intelligent filtering of job opportunities
- Improve job-seeker experience and hiring outcomes

### Policy Analysis

- Conduct impact analysis of policies on skills supply, demand, and mismatches
- Model and simulate the effect of policy changes on the labor market
- Enable data-driven policymaking and reforms

Overall, the Knowledge Graph would enable richer, connected labor market data and power more personalized, intelligent services for citizens and policymakers. It can enhance career navigation, skills anticipation, job matching, and data-driven policymaking. The Ministry could become an ecosystem enabler, through its trusted centralized LMIS, for the nation's workforce development and planning.