Université de Tunis

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Visual Display Ontology
VDO

Semantic Reasoning for Adaptive Display Systems

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Why Do Displays Need Intelligence?

- Displays today are static systems operating in dynamic, context-rich environments.

  - A monitor behaves **identically** whether the user is **fatigued** or **fresh**
  - An **OLED** screen shows **static content** for hours with **no burn-in awareness**
  - A **VR** headset runs at **low refresh rates** with **no motion sickness warning**

No system connects device capabilities to user wellbeing or hardware health

There is no unified, structured model that links:

- Device physical structure (what it is made of)
- Underlying technology (how it produces images)
- Component-level metrics (degradation, fatigue)
- Human biological effects (eye strain, motion sickness)
- Adaptive behavioral responses (mode switching, recommendations)

Current systems:

Manual (user settings) || Black-box (AI models)

Missing:

An explainable semantic reasoning layer

An ontology-driven reasoning system for visual display adaptation.

- **What it does:**
  - Models display devices as a **structured**, **layered knowledge graph**
  - Encodes domain rules as **logical axioms**
  - Lets a formal reasoner **automatically infer risks** and **required actions**
  - Connects physical properties all the way to human-facing decisions

Existing approaches:

Approach	How it works	Limitation
Spec-based (datasheets)	Describes hardware properties	Descriptive only — no reasoning
UX settings (manual)	User configures preferences	No semantic model, no automation
AI models	Neural networks optimize display	Black-box — not explainable

The gap:

No existing system combines semantic structure, explainable logic, and automatic adaptation in a single model.

Contribution

A multi-layer OWL 2 DL ontology for visual display systems with inference-driven intelligence.

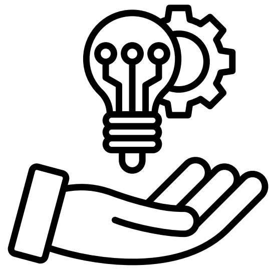
- **Property chains:** automatic propagation of knowledge across layers
  (**device → technology → component → material**)
- **Datatype reasoning:** numeric thresholds (latency, refresh rate, pixel fatigue percentage) **trigger** semantic class membership automatically
- **Context-aware adaptation:** user health states and hardware degradation states drive recommended display mode changes

EVOLUTION

We take existing hardware knowledge and formalize it into machine-readable logic that enables automatic inference.

REVOLUTION

We redefine displays to include **ScreenlessDisplay** and **NeuralInterface**, extending **beyond physical screens** and even bypassing the eye.
The **AI Awareness Engine** shifts the model from a passive output device to a context-aware adaptive agent.



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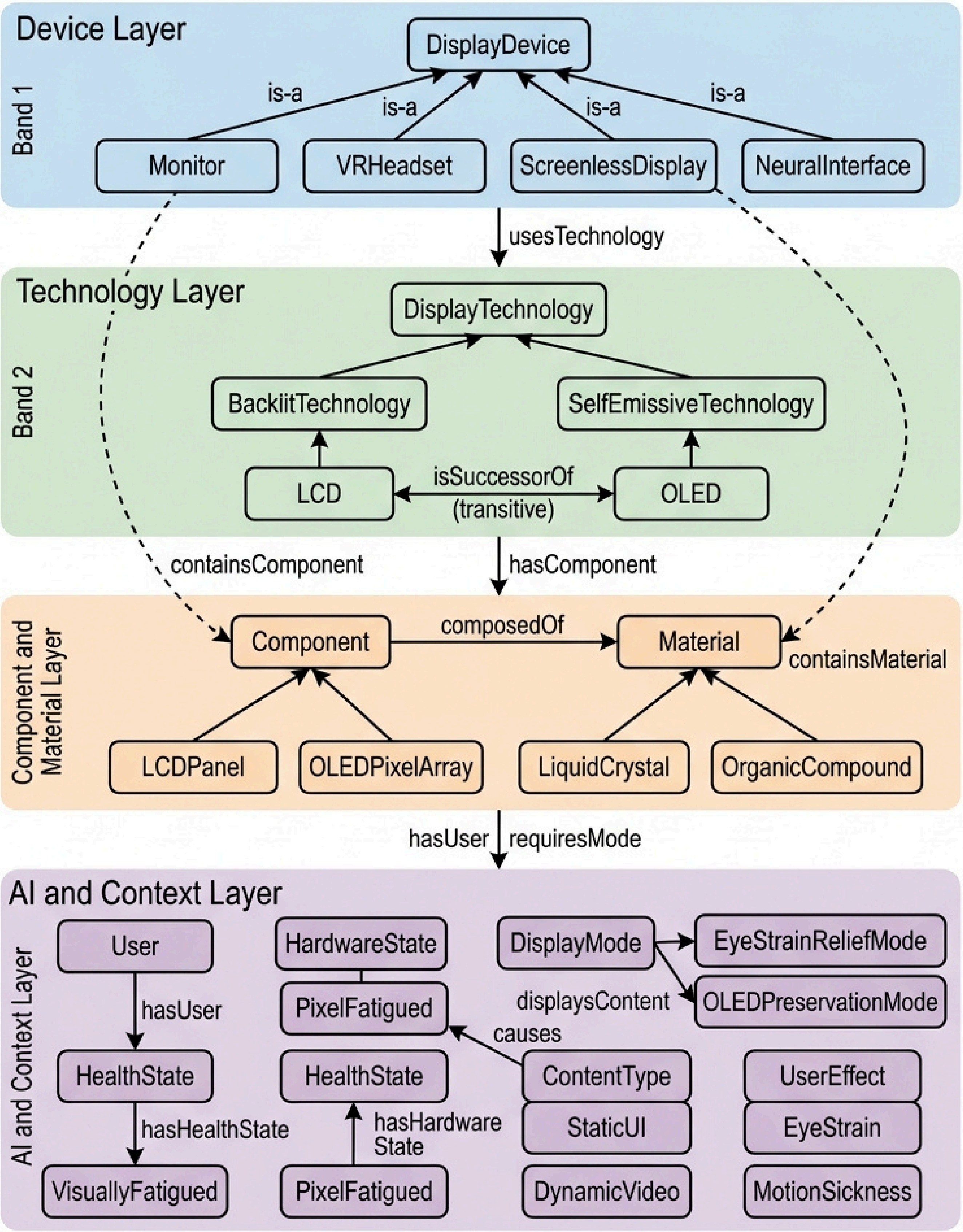
Ontology Architecture



Defined Classes (Reasoner Inferred)

NauseaInducingVR
VRHeadset + latency>=20 OR Hz<=90

SubZeroUnsuitableDevice
containsMaterial LiquidCrystal

HighDegradationRiskDevice
OrganicCompound + StaticUI

DeviceRequiringE–yeStrainRelief
User hasHealthState VisuallyFatigued

AtRiskOLED
pixelFatigue >= 70%

DeviceRequiring OLEDPreservation
containsComponent AtRiskOLED

→ subclass or asserted property
- - → property chain (inferred)
blue=devices
green=technology
orange=components
purple=context/AI
yellow=inferred

Three core properties:

- **usesTechnology:** connects a display device to its underlying display technology
- **hasComponent:** connects a technology to the physical component that implements it
- **composedOf:** connects a component to the material it is made from

Two derived properties

- **containsComponent:** derived: Device → Technology → Component
- **containsMaterial:** derived: Device → Technology → Component → Material

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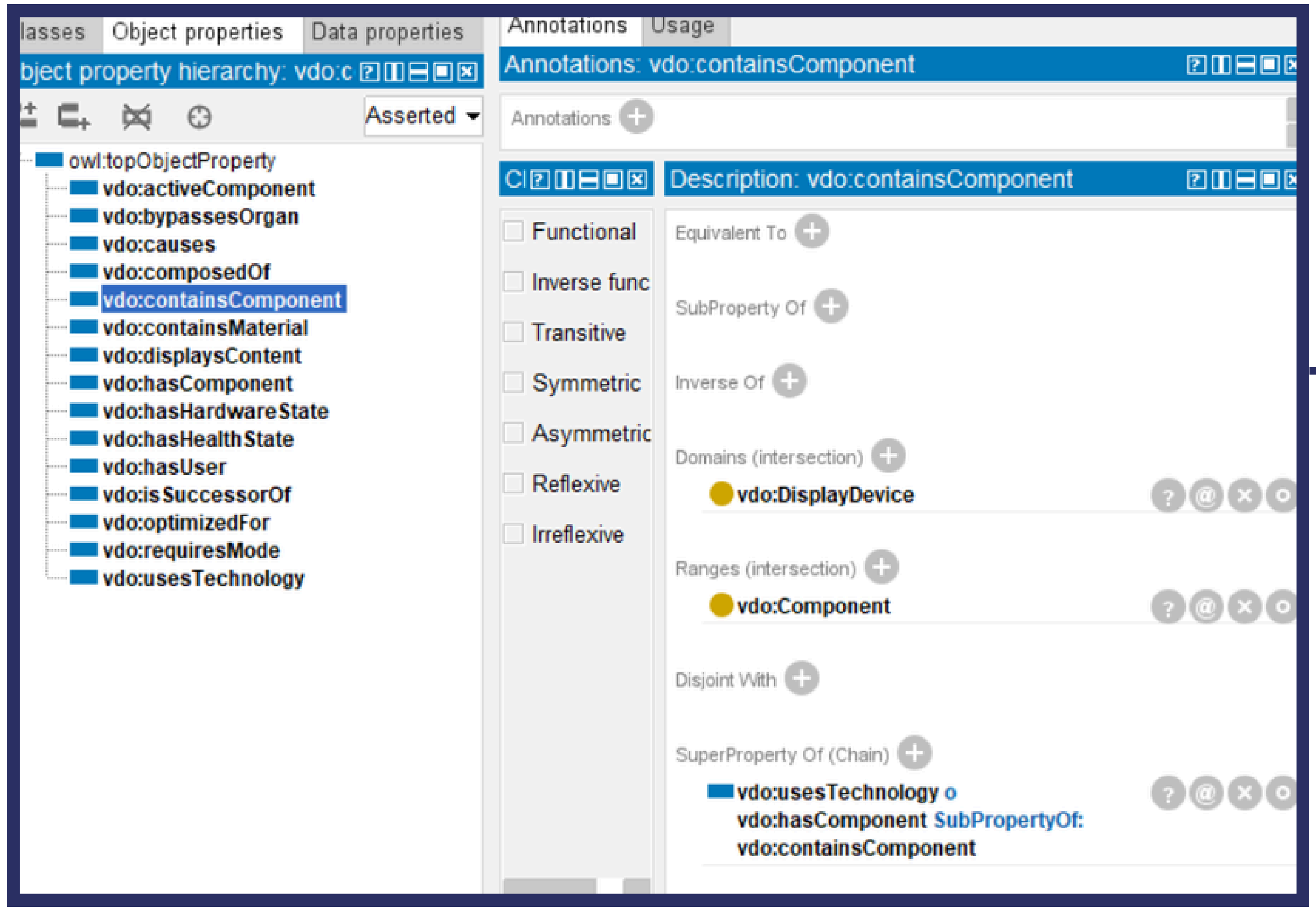
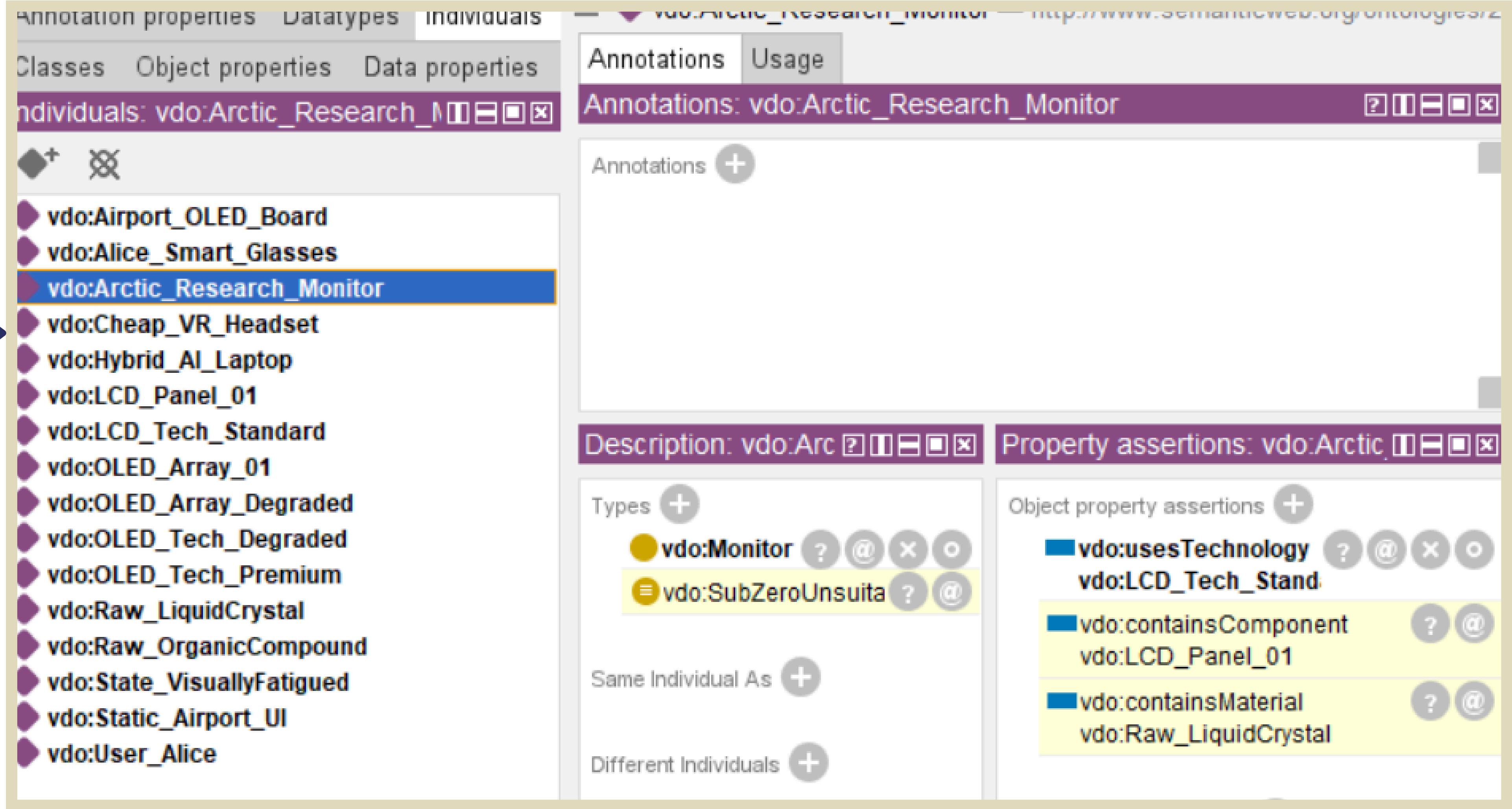
Property Chains

Property chains allow knowledge to travel across multiple layers without any manual intermediate assertion.

- **containsComponent** defined as: **usesTechnology** followed by **hasComponent**
- **containsMaterial** is defined as: **usesTechnology** followed by **hasComponent** followed by **composedOf**



RUNNING REASONER



The device is automatically classified as a SubZeroUnsuitableDevice — without any human labeling.

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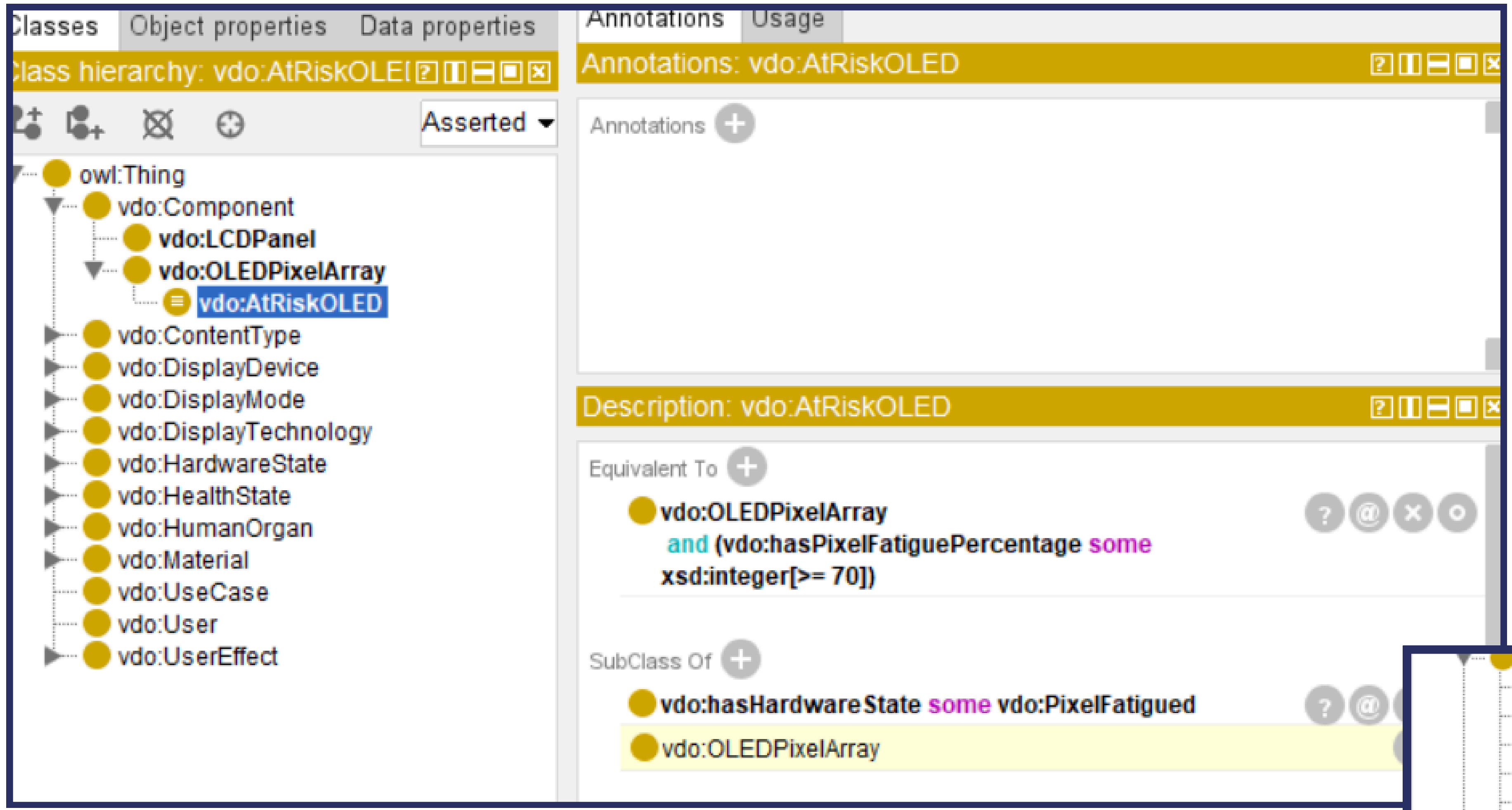
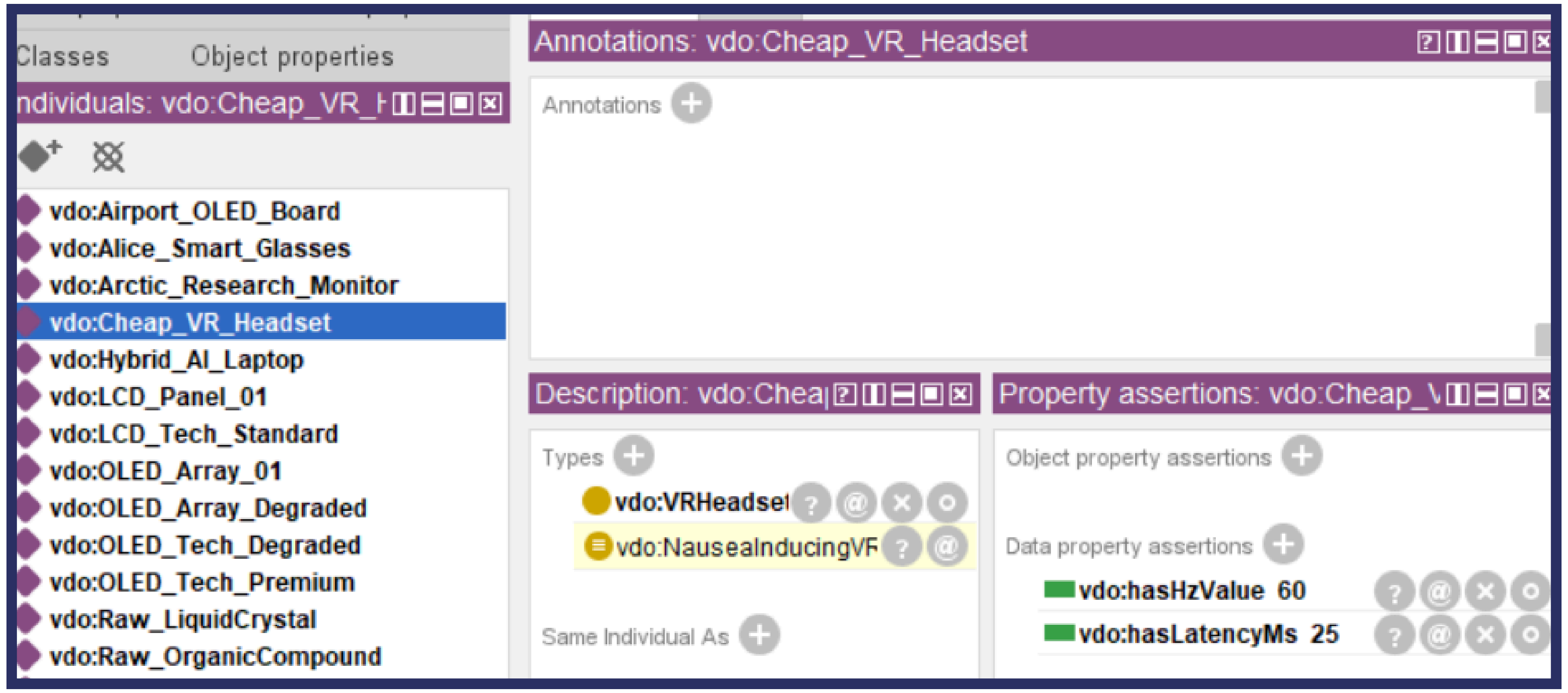
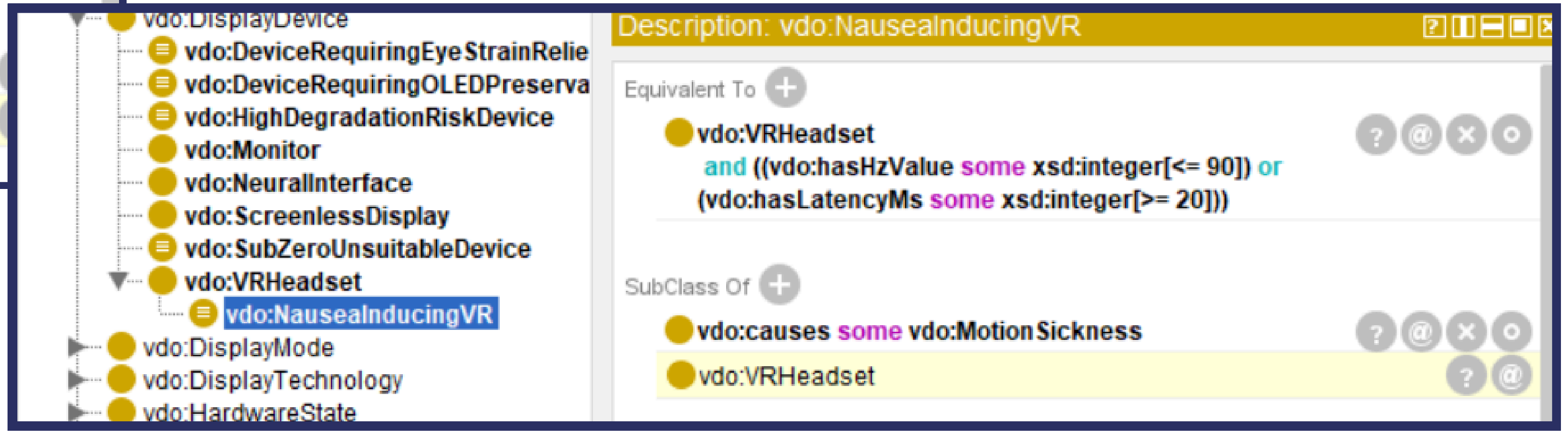
- **Latency (ms):** A VR headset with latency greater than or equal to 20 milliseconds is at risk of inducing motion sickness
- **Refresh rate (Hz):** A VR headset with refresh rate less than or equal to 90 Hz is at risk of inducing motion sickness
- **Pixel fatigue (%):** An OLED pixel array with fatigue greater than or equal to 70 percent is classified as at risk and enters a degraded hardware state







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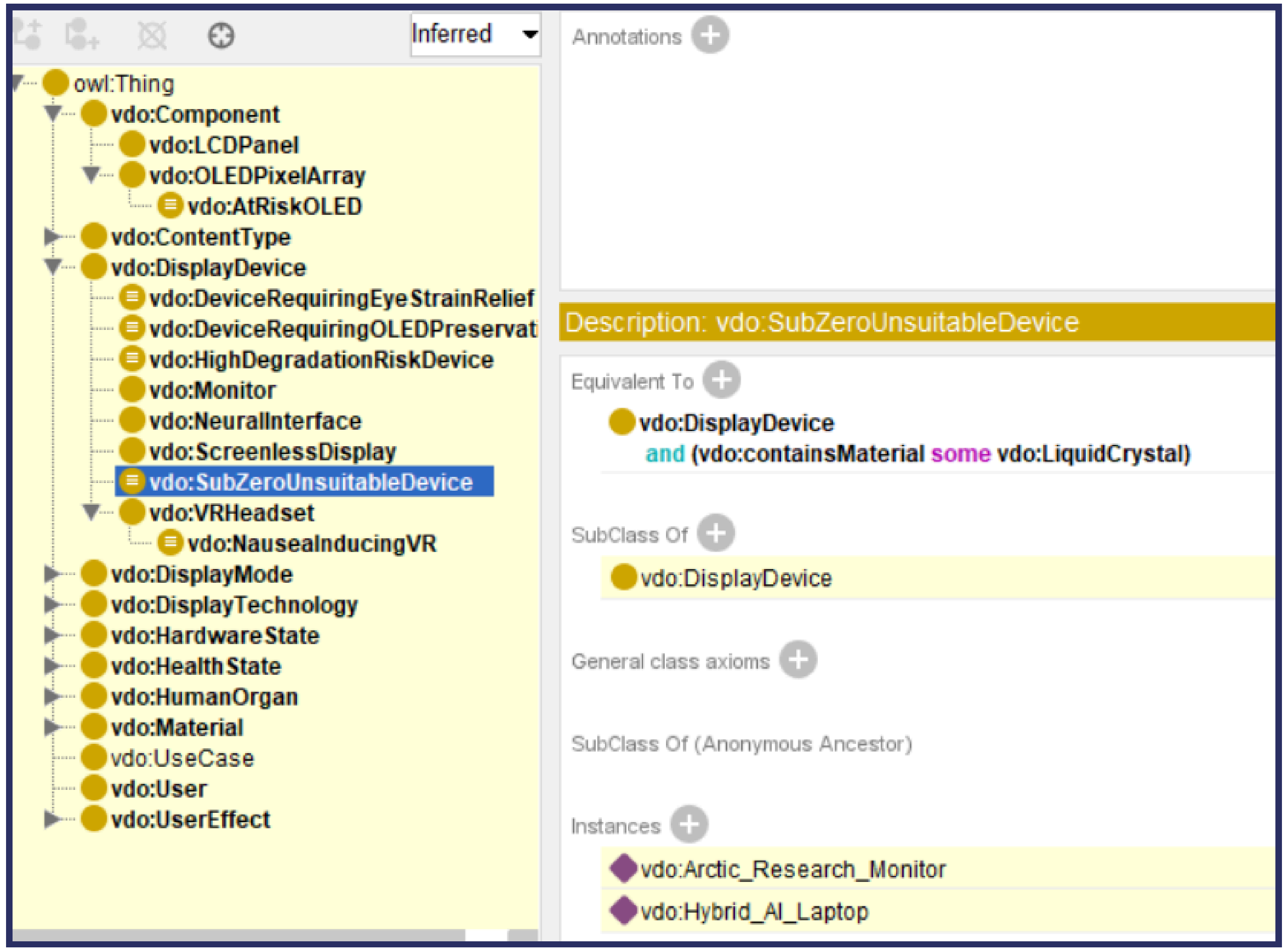
Defined Classes

six inferred classes are defined using owl:equivalentClass, not rdfs:subClassOf.



- **A subclass says: every member of A is also a member of B (one direction)**
- **An equivalent class says: A and B have exactly the same members (both directions)**

Class	What triggers it
NauseaInducingVR	VR headset with bad latency or low refresh
SubZeroUnsuitableDevice	Device containing Liquid Crystal material
HighDegradationRiskDevice	OLED device displaying static content
DeviceRequiringEyeStrainRelief	Device used by a visually fatigued user
AtRiskOLED	OLED component with pixel fatigue 70% or above
DeviceRequiringOLEDPreservation	Device containing an at-risk OLED component

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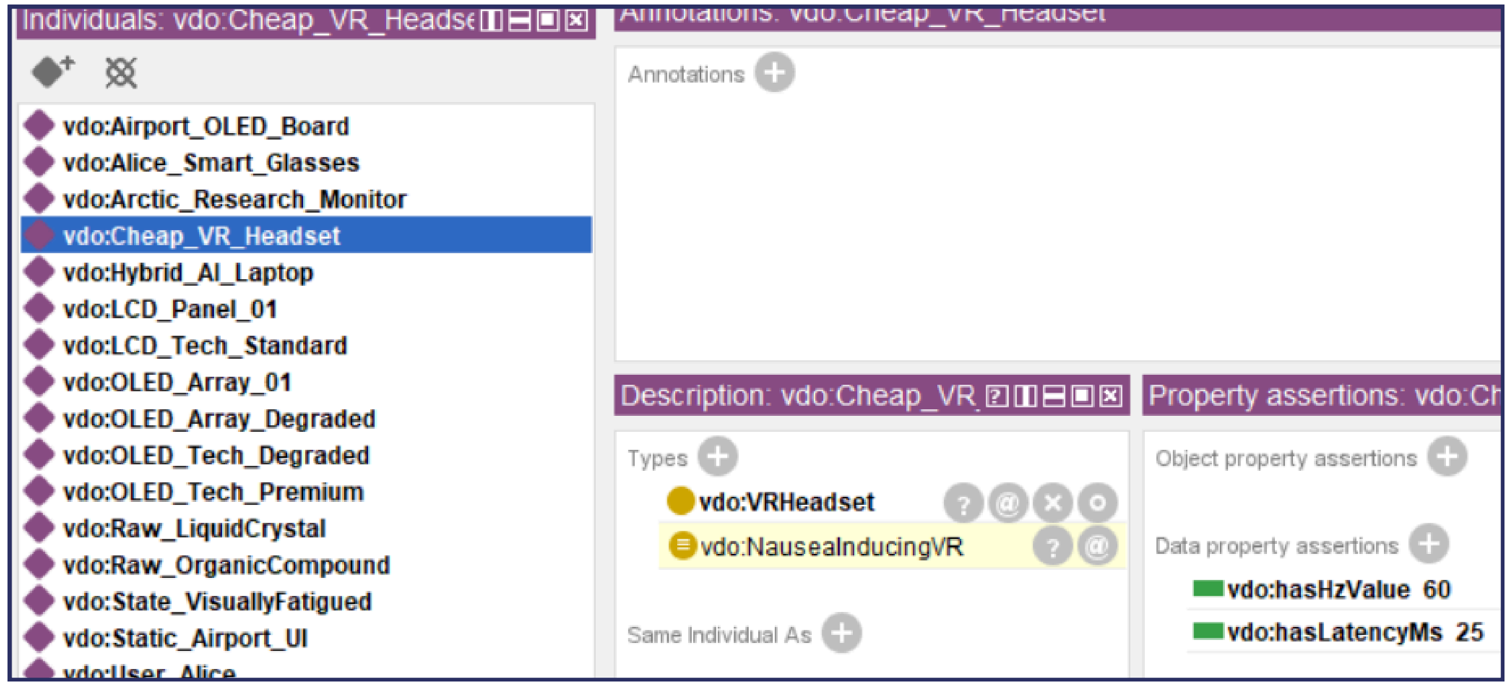
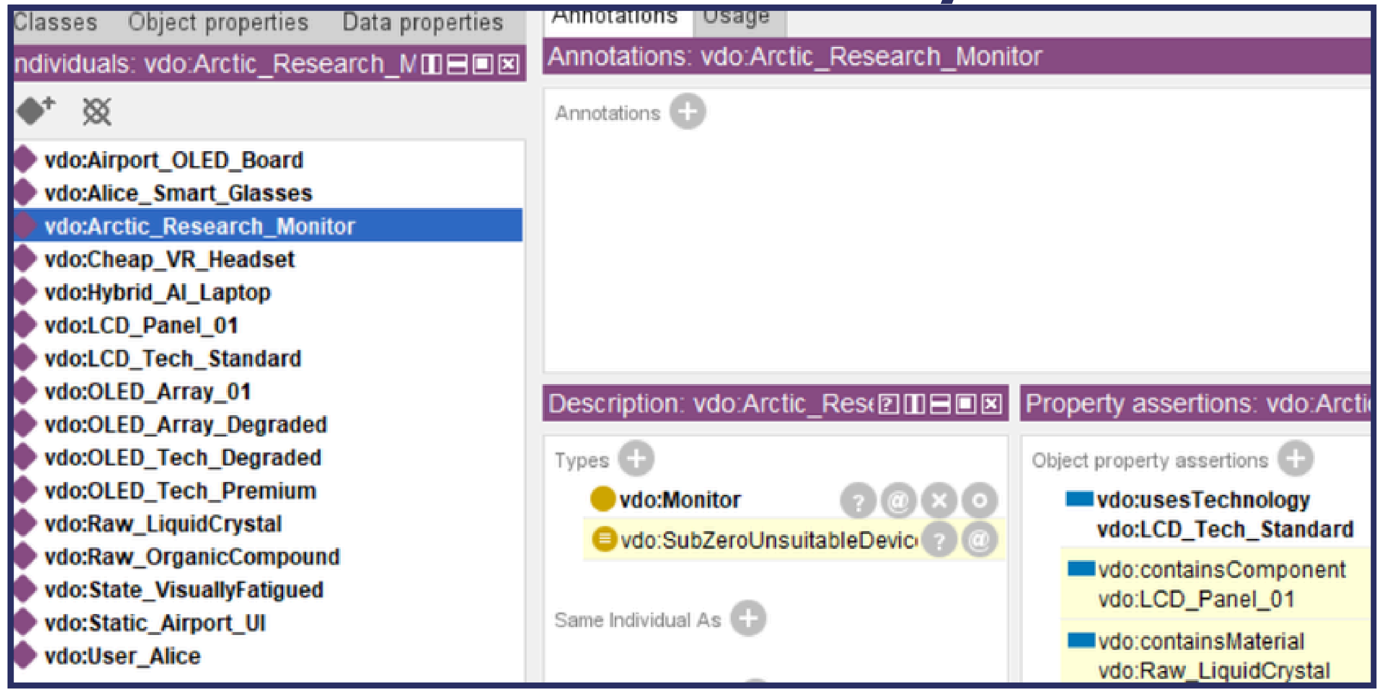
Use Case: VR Motion Sickness



The logic: The class NauseaInducingVR is defined as any VR headset that has latency at or above 20 milliseconds OR refresh rate at or below 90 Hz.

Use Case: Cold Unsuitability



The logic: The class SubZeroUnsuitableDevice is defined as any display device that contains liquid crystal material — reached through the containsMaterial property chain..

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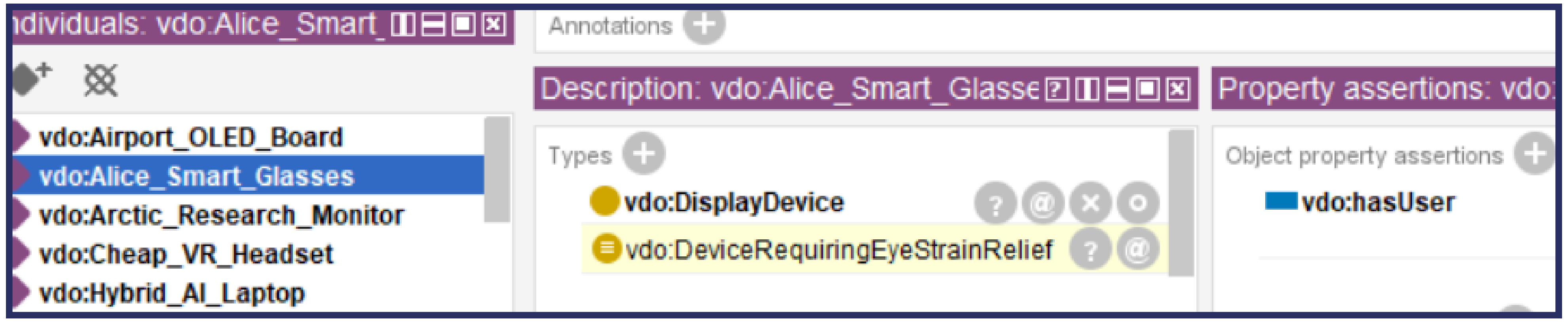
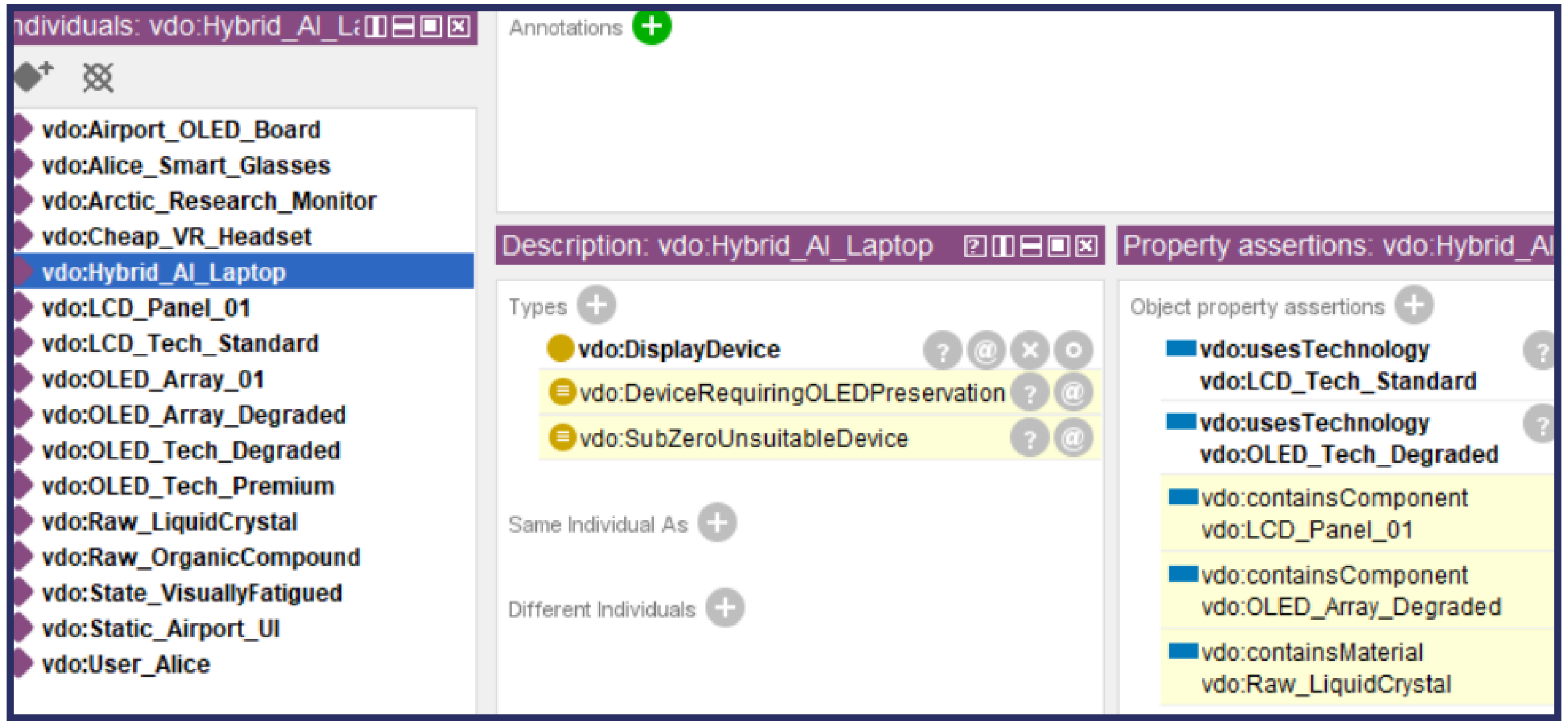
Use Case: User-Aware Adaptation



The logic: The class **DeviceRequiringEyeStrainRelief** is defined as any display device that has a user, where that user has a health state of **VisuallyFatigued**. This class is also a subclass of "**requiresMode some EyeStrainReliefMode**."

Use Case: Hardware-Aware Adaptation



The full chain:

1. The OLED pixel array has hasPixelFatiguePercentage = 85
2. The reasoner classifies it as AtRiskOLED (threshold is 70%)
3. AtRiskOLED is inferred to have hardware state PixelFatigued
4. The Hybrid AI Laptop uses a technology that contains this AtRiskOLED component
5. Therefore the laptop is classified as DeviceRequiringOLEDPreservation
6. Which is inferred to requiresMode OLEDPreservationMode

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What is automatically inferred from raw assertions:

- **Risk classification:** devices flagged for cold environments, burn-in, or motion sickness
- **Human effects:** motion sickness linked to VR headsets with bad metrics
- **Hardware states:** pixel fatigue above threshold triggers PixelFatigued state
- **Required display modes:** EyeStrainReliefMode and OLEDPreservationMode recommended automatically

The value:

- **Any new device added to the ontology with appropriate property assertions will be classified correctly without any additional rules or code.**

Tools and Components:

- Protégé 5.6
- OWL 2 DL
- HermiT reasoner
- Claude Sonnet 4.6 Thinking model (Documentation)
- Gemini 3 Pro Image (Visuals)
- SciSpace Ai / Perplexity (Research)

1. **Open World Assumption:** OWL assumes that missing information is unknown, not false.
2. **No disjointness axioms**
3. **No real-time data integration**

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Near-Term:

- **Disjointness** axioms between **sibling classes** to enable **consistency checking**
- Activate **hasPWMFrequency** with a **migraine trigger axiom** (any technology with PWM frequency below 240 Hz is a PotentialMigraineTrigger)
- Declare **UseCase subclasses** (Gaming, Reading, OutdoorUse) and wire the **optimizedFor** property

Longer-term(the Revolution roadmap):

- Add **MicroLED**, **E-Ink**, and **HolographicDisplay** as technology subclasses
- Add **ScreenlessDisplay** assertions and the **bypassesOrgan** property on **NeuralInterface**
- Introduce **EnvironmentalCondition** (ambient light, temperature) and connect it to device suitability rules
- Integrate a real sensor pipeline using **OWLready2** for live state updates
- Combine with an **AI perception layer** for full **neuro-symbolic** operation

From Display Devices Ontology —> to Adaptive Visual Experience Ontology.

The knowledge existed in spec sheets and research papers; this ontology makes it computable and self-reasoning.

The display is no longer something you look at, it is a system that looks back, reasons about you, and adapts.

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THANK YOU
For Your Attention

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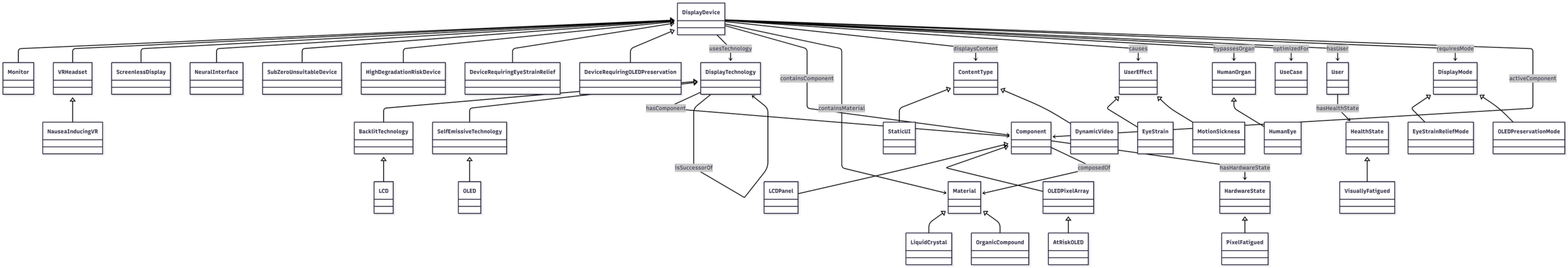
Appendix



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