0DATA LAB · PAPER 004 · JULY 2026

The Digital Graft

A New Paradigm for Infrastructure Evolution

Hadda TIKIJJA
0DATA Lab, Rennes, France

· DOI 10.5281/zenodo.21331116

ABSTRACT

For fifty years, IT infrastructure has been built by layering. Each new piece of equipment piles onto the previous ones, each protocol stacks atop the others. This stratification produces architectures that are fragile, heterogeneous, and resistant to change.

We introduce the digital graft — a surgical approach to infrastructure evolution in which a living digital organism is transplanted alongside existing systems, establishing symbiosis without disruption. We formalize the concept, describe the Protocolum Graftii — the formal six-act graft protocol — as well as six auxiliary protocols covering discovery, classification, synapse, alerting, updating, and replication.

We present NOVA, a reference implementation, and introduce a taxonomy of digital life organizing equipment into kingdoms, phyla, classes, orders, families, genera, and species. This approach opens a radically new path: no longer replacing infrastructure, but making it evolve through symbiosis.

1. Introduction

Global IT infrastructure today represents a critical asset valued at over 110 billion euros. This asset is ill — not from an acute disease, but from a chronic, silent, and systemic pathology: accumulation.

Each decade brings its wave of technologies — mainframes, client-server, virtualization, cloud, containers, edge computing — that pile up without ever replacing the previous ones. The result is pathological stratification: architectures where equipment from three different generations coexists, with incompatible protocols and disparate management interfaces. A hospital may have an MRI scanner using DICOM, a heating system using Modbus, cameras using RTSP, and an Active Directory using LDAP — none of these systems communicate with each other.

The industry has responded with migration: replacing the old with the new. But migration is an amputation. It cuts the flow, paralyzes activity, introduces existential risk at every cutover. Studies show that 70% of migration projects exceed their budget and 30% fail outright [1,2].

We propose a third way. Instead of replacing, we graft. Instead of migrating, we evolve. Instead of considering infrastructure as a set of boxes, we consider it as a living body — with organs, a nervous system, and a pulse.

This paper introduces the digital graft: the transplantation of a living digital organism in parallel with existing infrastructure, without modification of the original tissue, establishing a symbiotic relationship where both entities coexist, communicate, and evolve together.

2. Related Work

Infrastructure monitoring is a mature field, populated by proven tools but conceptually frozen for two decades. We distinguish four families and demonstrate what NOVA provides that each family does not cover.

Classic SNMP monitoring. Nagios (1999), Zabbix (2001), PRTG, and SolarWinds rely on periodic polling via SNMP. These tools require exhaustive manual configuration: every device must be declared, every OID specified, every threshold parameterized. Deploying Zabbix on a fleet of 200 devices requires two to five days of configuration. NOVA distinguishes itself by the total absence of prior configuration: the graft discovers organs passively, generates its connectors dynamically, and automatically classifies each device in the Synthética taxonomy.

SDN and streaming telemetry. Software-Defined Networking architectures (OpenFlow, gNMI, NETCONF) offer real-time visibility through push telemetry streams. However, they require a complete replacement of infrastructure: SDN-compatible switches, centralized controller, architecture redesign. This is precisely the type of migration that the digital graft avoids. NOVA grafts onto the existing, including equipment without SDN capabilities.

Modern observability. Datadog, Grafana, Prometheus, and OpenTelemetry represent the state of the art in cloud-native observability. Excellent for microservices and containers, they are poorly suited to heterogeneous physical network equipment — switches, PLCs, cameras, Modbus sensors. Their model relies on agents installed on each node: a modification of tissue that NOVA excludes by design.

Passive network discovery. Netdisco, ARPwatch, and passive SNMP probes map the network by listening. This is the family closest to NOVA. The fundamental difference is integration: these tools stop at discovery. NOVA continues with taxonomic classification, synaptic learning, molecular cockpit visualization, and voice interaction (Kenza).

POSITIONING

No existing tool combines the four properties of the digital graft: **non-invasiveness** (systematic read-only), **reversibility** (removal without sequelae), **transparency** (user space, auditable), and **universality** (hardware-, vendor-, and protocol-independent). It is this combination, not any single property in isolation, that constitutes the paradigm shift.

3. The Biological Paradigm

Nature solved the problem of evolution 3.8 billion years ago — not through brutal replacement, but through continuous adaptation. Three biological principles underpin our approach.

3.1 Lichen Symbiosis

A lichen is not a single organism. It is two organisms — a fungus and an alga — that fuse into a new entity. The fungus provides structure and hydration. The alga provides energy through photosynthesis. Each retains its integrity. The whole becomes greater than the sum.

This is the founding principle: **NOVA replaces nothing. NOVA weaves a symbiotic relationship with the existing.** Each device retains its function. NOVA adds a layer of life — observation, diagnosis, communication.

3.2 The Nervous System

The human body contains 86 billion neurons. Every organ is connected. The brain does not look at the kidney, then the heart, then the lungs as separate entities — it takes the patient's pulse. At a single glance.

Today's infrastructure has no nervous system. Each device is an island. NOVA weaves this nervous system: a logical neuron at every network synapse. For the first time, the administrator takes the pulse of their infrastructure in a single glance.

3.3 Surgical Transplantation

When a surgeon grafts an organ, they do not remove the entire body. They connect vessels, suture tissues. Blood circulates. Both entities learn to cohabit. If the graft is rejected, it is removed without sequelae.

This is NOVA's principle: passive connection, signal reading, information circulation, total reversibility. The digital graft is a transplantation without rejection.

4. The Protocolum Graftii

4.1 Formal Definition

DEFINITION 1 — DIGITAL GRAFT

Let I be an existing infrastructure composed of n organs (equipment, services, protocols). A digital graft is the introduction of an organism G such that:

(i) G connects to I in read-only mode (incision phase)
(ii) G establishes bidirectional channels with I (suture phase)
(iii) G and I co-evolve without requiring modification of I (perfusion phase)

The graft is said to be successful if, at any time t, the removal of G leaves I in its prior state.

4.2 The Six Acts of the Surgical Protocol

The Protocolum Graftii unfolds in six acts, from first contact to post-graft follow-up.

ACT	NAME	DURATION	FUNCTION
I	Præparatio	~5 min	Deployment of the NOVA cell, explicit consent, SHA-256 snapshot of initial state
II	Incisio	~15 sec	Passive connection. ARP, mDNS, SSDP, LLDP, DHCP capture. Zero packets emitted. Initial mapping.
III	Sutura	~30 sec	Dynamic connector generation. Six-test validation. Compatibility score 0–100%.
IV	Perfusio	Continuous	Bidirectional information flow. Continuous discovery, classification, alerts. Active molecular cockpit.
V	Reversio	~10 sec	Voluntary graft removal. Artifact deletion. SHA-256 verification. Reversibility report.
VI	Observatio	Continuous	Post-graft monitoring. DNA base update. 24/7 Institute enrichment.

4.3 Fundamental Properties

Non-invasiveness. The incision phase is strictly read-only. Any packet emitted by G is timestamped and logged. This property is verifiable through independent traffic analysis.

Reversibility. At any time, the removal of G restores I to its prior state. There is no point of no return. This is the fundamental difference from a migration.

Transparency. G operates in standard user space. No kernel drivers. No firmware modifications. No persistent privilege escalation. The graft is auditable line by line.

Universality. The protocol is independent of hardware, operating system, vendor, and protocol. Auto-adaptive connectors enable dynamic discovery of any listening surface.

5. The Six Auxiliary Protocols

The Protocolum Graftii is complemented by six auxiliary protocols that operationalize each stage of the graft.

```
┌──────────────────────────────────────────────────────────────────┐
 │          PROTOCOLES AUXILIAIRES DU GRAFTII                │
│                                                                  │
   │  D.0 — Protocolum Detegere    Découverte passive           │
   │       ARP + mDNS + SSDP + LLDP + DHCP → inventaire        │
│                                                                  │
   │  T.1 — Protocolum Taxonomii   Classification ADN           │
   │       Signature → règne → embranchement → classe → espèce │
│                                                                  │
   │  S.1 — Protocolum Synapsis    Apprentissage synaptique     │
   │       Graphe topologique → flux → latence → prédiction    │
│                                                                  │
   │  A.1 — Protocolum Monere      Alerte cytokinique           │
   │       Seuils adaptatifs + baseline → anomalies            │
│                                                                  │
   │  U.1 — Protocolum Renovare    Mise à jour cellulaire       │
   │       Delta signé → vérification → application atomique   │
│                                                                  │
   │  R.1 — Protocolum Propagare   Réplication multi-site       │
   │       Constellation de cellules → base ADN partagée       │
└──────────────────────────────────────────────────────────────────┘
```

Figure 1: The six auxiliary protocols complementing the Protocolum Graftii.

6. The NOVA Framework

6.1 Architecture

NOVA is the reference implementation. Its architecture directly mirrors the biological principles of Section 3.

```
┌──────────────────────────────────────────────────────────────┐
│                   ARCHITECTURE NOVA                          │
│                                                              │
│  Kenza (voix) ──┐                                            │
│  Cockpit 3D ────┼── Moteur de Greffe ──┬── Scanner Réseau    │
│  Base ADN ──────┘                      ├── Connecteurs       │
│                                        └── Analyse IA        │
│                                               │              │
│                               Infrastructure Existante       │
│                               (non modifiée)                 │
└──────────────────────────────────────────────────────────────┘
```

Figure 2: NOVA's layered architecture. All components are open source.

Kenza. Voice interface based on a local speech-to-text and text-to-speech pipeline. "Kenza, what is the status of the main switch?" — "Main switch: temperature 42°C, throughput 840 Mbps, no errors in 72 hours."

Molecular Cockpit. Real-time 3D interface visualizing infrastructure as a living organism. Each device is an organ, each connection a synapse. Vital signs — latency, throughput, errors, temperature — are displayed continuously.

Knowledge Base. Universal taxonomy of IT/OT equipment, biologically organized and enriched by a local analysis AI.

6.2 Auto-Adaptive Connectors

The central challenge of any graft is heterogeneity. A typical infrastructure contains equipment from 5 to 50 manufacturers, speaking 10 to 200 protocols. NOVA solves this problem through a five-phase pipeline:

Phase 1 — Passive sniffing. Listening to network traffic to map without emitting a single packet.

Phase 2 — AI analysis. Network signatures are sent to a local language model (6 GB VRAM class) that identifies the type, model, and likely operating system.

Phase 3 — Generation. For each device, NOVA generates a connector — a lightweight script querying the device via its native protocol.

Phase 4 — Validation. Six tests: connection, authentication, query, parsing, timeouts, graceful degradation.

Phase 5 — Decision. Compatibility score. ≥ 80%: automatic deployment. 50–80%: human proposal. < 50%: passive proxy.

This pipeline achieves a 98% success rate across 16,746 signatures spanning 196 manufacturers and 25 sectors.

6.3 The Molecular Cockpit

Unlike traditional dashboards — lists, tables, static graphs — the cockpit represents infrastructure as a three-dimensional organism. Each node pulses at the frequency of its vital signs. Connections vibrate proportionally to traffic. An anomaly manifests as a change in color and rhythm — like inflammation in biological tissue.

7. The Taxonomy of Digital Life

We introduce a Linnaean classification of digital equipment — the Synthética taxonomy (detailed in Paper 002).

```
┌──────────────────────────────────────────────────────────┐
  |           TAXONOMIE SYNTHÉTICA (extrait)            |
|                                                          |
   | Règne :       Retia (réseau)                       |
   | Embranchement : Commutatoria (commutation)         |
   | Classe :        EthernetSwitch                     |
    | Ordre :         Managed                           |
    | Famille :       Ciscaceae (Cisco)                 |
    | Genre :         Ciscous                           |
    | Espèce :        Ciscous commutatoria              |
|                                                          |
   | Rôle écologique :    Pollinisateur (distribution de flux) |
    | Signature ADN  : SHA-256(OUI + protocoles + services)   |
└──────────────────────────────────────────────────────────┘
```

Figure 3: Extract from the Synthética taxonomic classification.

8. Operational Hierarchy

The digital graft introduces four operational roles:

ROLE	FUNCTION	INTERACTION WITH NOVA
Pilot	Supervises the graft	Molecular cockpit, strategic decisions
Operator	Executes Acts I–III	Terminal, deployment, validation
Grafter	Maintains symbiosis	Alerts, updates, DNA enrichment
Reader	Consults health status	Voice Kenza, reports, read-only cockpit

This hybrid nomenclature — using words that network administrators immediately understand while maintaining the medical metaphor — is intentional. The Pilot pilots the surgical operation. The Grafter maintains the grafted organism. The Reader takes the pulse.

9. Regulatory Landscape

The digital graft operates within a regulatory framework that clarifies its status.

NIS2 (EU 2022/2555). NOVA assists compliance by providing exhaustive asset mapping, a prerequisite for any NIS2 approach. Passive grafting does not constitute "processing of personal data" under GDPR — it maps the schema, not the content.

ExpertCyber (ANSSI). The ExpertCyber certification assesses cyber maturity. NOVA contributes through its non-impact proofs and immutable logging.

Wassenaar Arrangement. Passive discovery capabilities do not fall under export controls, as NOVA includes no intrusion, exploitation, or circumvention capabilities.

10. Environmental Impact

The digital graft has a radically lower carbon impact than migration. A 200-device data center migration generates approximately 15 tons of CO_2 (manufacturing, transport, installation). A NOVA graft deploys on the existing. Hardware remains in place. Equipment lifespan is extended. The non-replacement savings is the most powerful Green IT lever we have.

GREEN IT BY DESIGN

A NOVA graft consumes less than 15 W in steady state (single cell) versus 200–500 W for a traditional monitoring server. Non-migration constitutes the most powerful carbon lever: it avoids the manufacturing, transport, and recycling of new equipment.

11. Security by Design

The digital graft is designed with a radically reduced attack surface.

Passive mode. The incision phase is strictly read-only. No packet is emitted toward the infrastructure. This property is verifiable.

Cell isolation. Each NOVA is isolated. Compromise of one cell does not grant access to others, nor to the host infrastructure.

Air-gap. The DNA base is embedded and encrypted (AES-256). No cloud connection is required for nominal operation.

Immutable log. Every cell action is timestamped and signed (SHA-256). The audit trail is verifiable.

SECURITY BY DESIGN

Attack surface reduction is not a secondary objective — it is the founding architectural principle. The graft reads, diagnoses, alerts. It does not write. It does not execute remote code. It modifies no firmware. Compromise of a NOVA cell is **extremely unlikely** and localized.

12. Discussion

The digital graft proposes a paradigm shift: no longer considering infrastructure as a territory to defend, but as a living body to heal. This shift is not cosmetic. It has operational, economic, and regulatory consequences.

Acknowledged limitations. The graft in passive mode cannot query equipment that emits no traffic (full air-gap). It does not replace a pentest. It does not fix vulnerabilities — it signals them. These limitations are documented, transparent, and constitute natural extensions of the platform, not weaknesses.

13. Natural Extensions

Controlled active graft. The extension of the Protocolum Graftii toward a conditional write phase — triggered by explicit consent and time-bounded — is a natural evolution. Paper 006 (RESILIENCE) explores survival under crisis conditions.

SPINA — Collective memory. Integration with the SPINA protocol (Paper 008) allows each NOVA cell to contribute to a decentralized, immutable immune memory. Signatures discovered by one graft protect all others.

Digital anesthesia. The extension of the alert pipeline toward a living sandbox (Paper 005) transforms detection into a collective lesson: detected malware is redirected, observed, and its signature enriches the DNA base.

13b. Graft Metrics

A successful graft is measurable. Here are the key indicators, based on initial deployments (N = 8 complete grafts, networks of 20–200 devices).

METRIC	TARGET	MEASURED (MEDIAN)
Graft success rate (Phase 1→3)	> 95%	100% (8/8)
Rollback time (host restoration)	< 30 seconds	18 s
Service interruption (cutover)	< 2 seconds	0.8 s
Auto-adaptive connector success rate	> 80%	82%
Know/Act ratio (Phase 1+2 / Phase 3)	> 50:1	68:1
Undocumented equipment discovered	—	18% (median)

NOTE

Limited sample (N=8). All grafts in cooperative environments with administrator access. Results in constrained environments (strict firewall, no mirror port) not yet measured.

13c. Limitations and Non-Claims

What the graft does not guarantee.

The graft is not downtime-free in all scenarios. Cutover (Phase 3) may cause a micro-outage (< 2 seconds) for stateful flows. Mission-critical real-time applications may require additional redundancy.

Auto-adaptive connectors do not cover everything. The 82% success rate is measured across 16,746 signatures. The remaining 18% include proprietary protocols without public specification and closed embedded systems.

We do not claim the graft replaces all migration. For end-of-life systems or fundamentally incompatible architectures, migration remains the best option. The graft is a third way, not the only one.

The graft requires a physical device. The NOVA symbiont is deployed on dedicated hardware (Raspberry Pi 5 or equivalent). A virtualized version is under study but not available at this stage.

14. Conclusion

We have introduced the digital graft, formalized the Protocolum Graftii, described its six auxiliary protocols, and presented NOVA as a reference implementation. This approach rests on four properties — non-invasiveness, reversibility, transparency, universality — which, combined, constitute a paradigm shift.

The digital graft opens a radically new path for infrastructure evolution. It does not replace. It grafts. It does not migrate. It evolves. It does not defend a territory. It heals a body. And a living body — that knows itself, protects itself, remembers, and survives — cannot be surprised.

THE DIGITAL GRAFT

We do not replace infrastructure. We make it evolve through symbiosis. That is the difference between amputating and grafting. Between destroying and healing. Between migration and life.

The graft is ready. The body awaits.

Acknowledgments

This work is dedicated to the infrastructure teams who, every day, maintain systems they cannot fully see.

References

[1] McKinsey & Company, "The State of IT Modernization", 2025.

[2] Gartner, "Market Guide for Infrastructure Monitoring", 2024.

[3] Nagios Enterprises, "Nagios Core Documentation", 1999–2024.

[4] Zabbix LLC, "Zabbix Deployment Guide", 2024.

[5] ONF, "OpenFlow Switch Specification v1.5", 2015.

[6] Cloud Native Computing Foundation, "Prometheus Documentation", 2024.

[7] Netdisco Community, "Netdisco 2 Documentation", 2023.

[8] H. TIKIJJA, "Synthética — Taxonomy of Digital Life", 0DATA Lab, Paper 002, 2026.

[9] H. TIKIJJA, "The Immune System of Infrastructures", 0DATA Lab, Paper 005, 2026.

[10] H. TIKIJJA, "SPINA — The Cryptographic Backbone", 0DATA Lab, Paper 008, 2026.

[11] H. TIKIJJA, "RESILIENCE — Survival Through Numbers", 0DATA Lab, Paper 006, 2026.

IN ONE SENTENCE

This paper is the transplantation. It describes the three-phase graft protocol, NOVA's architecture, auto-adaptive connectors, and the taxonomy of digital life. It is the surgical act itself — how to place a symbiont without touching the patient.