IGNITION
DESIGN LABS

TECHNICAL WHITE PAPER

# SD-WiFi
# Carrier Wi-Fi Offload

Integrating Wi-Fi as a first-class radio access technology inside the 3GPP core — and the Hyper-Cellular 5G network that makes it economic.

# The problem operators actually have

### 5G went high-band. Buildings did not get thinner.

Demand for wireless data keeps climbing and 5G deployment keeps accelerating, but in the places where people actually use their phones, the experience often falls short of what the technology promises.

The first issue is **indoor coverage**. The high frequencies that give 5G its capacity — 2.6 GHz, 3.5 GHz, 4.8 GHz — are precisely the frequencies that struggle to penetrate concrete, glass and steel. In dense urban high-rises, signal quality indoors degrades sharply. This has become one of the most significant obstacles to 5G adoption, and it is not a problem that more of the same spectrum solves.

The second is **siting**. Operators encounter substantial resistance from residents when building stations inside communities. Add suboptimal location choices and high construction costs, and network expansion slows exactly where demand is highest.

> **The numbers are unforgiving.** Over 60% of network complaints relate to coverage, and roughly 40% of those concern voice. Every one of those complaints carries a compensation cost, and eventually a churn cost.

## Why Wi-Fi is the answer, and why it hasn't been

Wi-Fi delivers high bandwidth at a low cost per bit, and it works indoors by construction. Offloading traffic to Wi-Fi is the most cost-effective way to relieve congestion that exists.

What has held it back is that Wi-Fi has historically sat *outside* the operator's network — a separate SSID, a separate login, a separate policy domain, a separate support queue. Users notice the seam, and they resent it.

IDL's SD-WiFi closes that seam by integrating Wi-Fi into the 3GPP core as an alternate radio access technology, so that a subscriber's identity, policy and services follow them across both networks without their ever being asked to think about it.

# Hyper-Cellular 5G

## A different network architecture, not a bigger one.

The Hyper-Cellular 5G Network applies SDN and NFV to enable end-to-end network slicing. The radio access layer integrates multiple access technologies — 5G, 4G and Wi-Fi — across macro, micro and pico cells, under unified control.

The point is not that this is more elegant. The point is what it does to the economics:

| 30%+ | 99.999% | 100k+ |
|---|---|---|
| reduction in 5G construction cost | signal access reliability | access points under management |

### What changes

- **Construction and energy cost fall.** The design reduces build cost by over 30% and cuts energy consumption — improvements that land directly on profitability, not on a slide.
- **Signal penetration improves** without new spectrum. Software-defined radio and software-defined access make better use of the frequencies the operator already holds, particularly in high-rise interiors.
- **Community resistance drops.** Less physical infrastructure, under unified control, defuses the radiation and siting objections that stall deployments in residential areas.
- **Wi-Fi-only devices join the party.** Integrating disparate access networks — 4G, 5G, Wi-Fi, IoT — extends 5G-era services to devices that have no cellular radio at all.

Users can place and receive calls over Wi-Fi from the phone's native dialer. No app, no second identity, no explanation required. That is the whole test of whether convergence is real.

# Two ways into the core

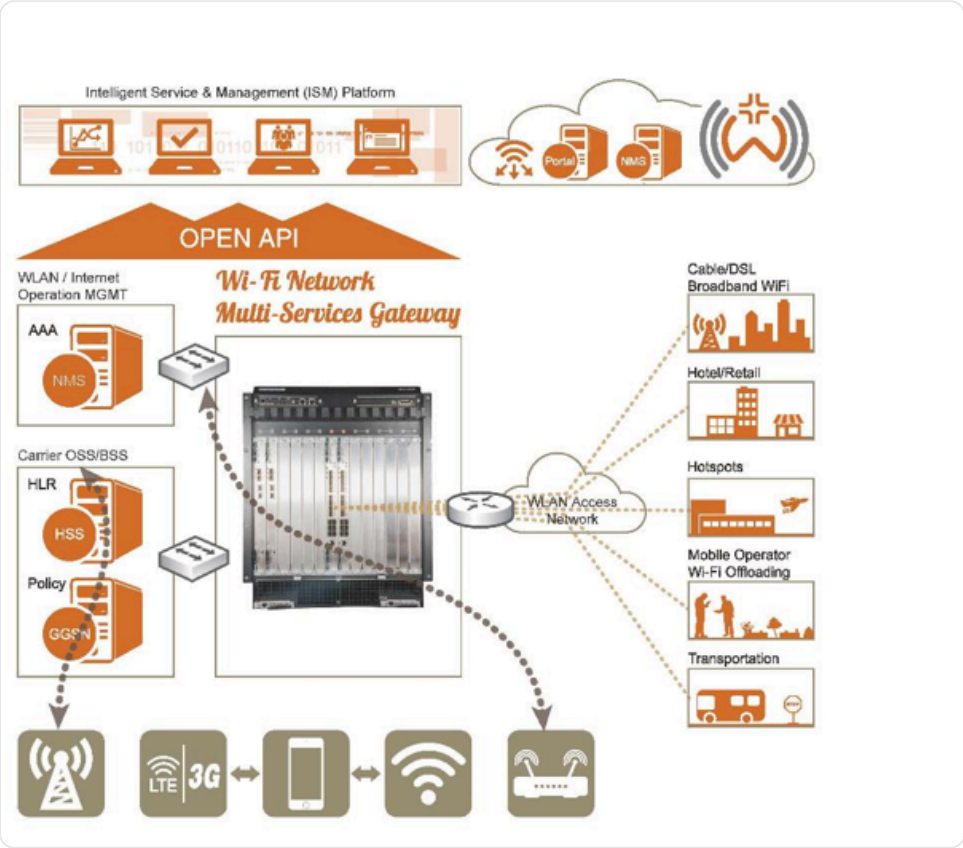
## Choose by how much control and visibility you need.

### Managed Offload

Wi-Fi extends the core through its authentication and policy systems. Credentials already on the SIM (EAP-SIM/AKA) authenticate the user; the AAA server talks to HSS/HLR to verify them, and PCRF applies the same usage policy the subscriber has on cellular. Lighter to deploy.

### Integrated Offload

Wi-Fi traffic is tunneled — GRE or IPSec — to a security gateway and into the 3GPP packet core via GTP. The result is full feature parity: voice, messaging, parental controls, and seamless mobility, with complete visibility of user context.




SD-WiFi topology — multi-service gateway, AAA and policy integration, across venue types

### Integration is not a science project

IDL's WLAN integrates with the major AAA vendors over RADIUS, so authentication and policy enforcement work against the systems the operator already runs, rather than requiring a parallel stack.

# Wi-Fi Calling (VoWiFi)

**The cheapest indoor voice coverage you will ever build is the Wi-Fi already installed.**

VoWiFi is the practical answer to indoor voice coverage where cellular is weak or absent. It complements VoLTE and VoNR within the 3GPP framework rather than competing with them, and it runs on infrastructure the subscriber has already paid for.

## Standards, briefly

- **4G integration** follows 3GPP TS 23.402: non-trusted Wi-Fi access reaches the EPC through an ePDG over the S2b interface — the same core that carries VoLTE, which is what makes handover between the two seamless.
- **ePDG to device** uses the SWu interface: IKEv2 for control, user data inside an IPSec tunnel.
- **5G SA** introduces S2b-C and S2b-U between the ePDG and the 5G core (SMF+PGW-C, UPF+PGW-U), with S6b and SWx carrying AAA interactions.
- Per 3GPP TS 23.501, the ePDG can be dual-connected to both the 5G and 4G cores — so this is a migration you can start before your core finishes its own.

## What it returns

- Indoor coverage where 5G penetration fails — without building anything
- Lower compensation expense on coverage and voice complaints
- Free domestic VoWiFi and cheaper international roaming, which subscribers notice and stay for

# Centrally managed carrier Wi-Fi

**Public Wi-Fi is no longer a free hotspot. It is infrastructure.**

Modern venue deployments must be reliable and secure, must carry both offload traffic and the venue owner's private services, and must support the value-added services that make Wi-Fi worth monetizing. That calls for a gateway, not a pile of access points.

## The Wireless Access Gateway

The WAG provides mobility and policy enforcement for user devices, and acts as a common gateway across many remote tunnel devices. It establishes IP connections to radio nodes across the wide area and controls Wi-Fi services centrally.

Technically the interesting part is the **wide-area Layer 2 domain**. Layer 2 gives faster session persistence and mobility than Layer 3, but broadcast domains are normally kept geographically small for exactly that reason — they are messaging-intensive. By building Layer 2 tunnels (SoftGRE, EtherIP) over a routed IP network, IDL creates wide-area Layer 2 networks that still sustain enormous transaction rates, while preserving seamless mobility at the MAC layer.

Dense aggregation at the WAG, with a high-performance forwarding plane, is also what makes cloud-based services injectable into the subscriber's traffic — content filtering and parental control among them.

- Multi-vendor Wi-Fi aggregation via GRE, EtherIP, CAPWAP or VLAN
- AAA proxy and load balancing; policy enforcement per AP, per VLAN or per user
- Carrier-grade NAT and stateful firewall; high-scale DHCP; full IPv6 and dual-stack
- Content filtering and malware/phishing protection; service function chaining
- Lawful intercept support; analytics and statistics

## Passpoint / Hotspot 2.0

Passpoint removes the obstacles to silent, secure public Wi-Fi access. Rather than tying each service provider to its own SSID, a single SSID stands in front of many providers with whom the subscriber already has a relationship. The device learns which providers are available, matches them against its subscriptions, and authenticates with the best option — with mutual authentication and over-the-air encryption made mandatory.

# Where it deploys

Five scenarios, one architecture.

### 1 · Dense urban areas

Macro 5G remains the primary layer; Wi-Fi 6 access points fill the coverage holes it leaves — transport hubs, malls, stadiums, city centres.

### 2 · Branches and SMBs

For chain stores and branch offices, Wi-Fi carries the majority of indoor connectivity while 5G acts as a supplementary channel. Fibre, 5G via SD-WAN, or CPE serves as the WAN interface.

### 3 · Residential communities

Gigabit Wi-Fi covers what 5G cannot reach indoors. Integrated with the core, residents get continuity rather than a handoff they can feel.

### 4 · Campuses, stadiums and museums

Indoors — dormitories, exhibition halls — Wi-Fi is the primary access technology, with outdoor areas held by 5G.

### 5 · Rural revitalization

700 MHz 5G provides the backbone; Wi-Fi handles terminal access. Together they deliver the coverage that education, healthcare and local economic development depend on, at a cost that makes rural deployment viable at all.

> **Proven at scale.** A Tier-1 operator in East Asia runs a converged 4G + Wi-Fi network built on this approach, with over 100,000 access points deployed and centrally managed nationwide — one of the largest integrated Wi-Fi and cellular systems in the world.

# About Ignition Design Labs

Ignition Design Labs (IDL) is a market leader in next-generation carrier-grade convergent Wi-Fi and 4G/5G wireless access technologies.

IDL has distinguished itself in the telecommunications sector most notably through its partnership with a Tier-1 operator in East Asia serving over 100 million subscribers — a collaboration that produced one of the world's largest integrated Wi-Fi and cellular systems, with over 400,000 access points across the capital area.

Beyond convergence, IDL addresses the user-experience problems of large-area Wi-Fi coverage: scalability, cognitive radio management, and integration with 4G/5G. It applies AI to network management and IoT security so that customers gain a better experience while spending less on maintenance.

IDL is headquartered in Silicon Valley, with R&D in Taiwan.

### Related solutions

- **SD-Edge** — vCPE and uCPE: a fully virtualized, software-defined carrier edge
- **SD-Access** — a zero-trust campus fabric that does not require replacing your switches
- **SD-Branch** — networking, security and SD-WAN converged into one gateway
- **MDU** — one SSID for the whole property, a private network for every unit
- **AIOps** — from reactive monitoring to a network that explains itself
- **Security** — secure gateway and DPI engine

> Learn more at **ignitiondl.com/solutions**