Standards and Mobility Innovation Lab

Nov, 2024

AI-Native Communication for 6G Site-Specific RAN Solution

Samsung Research

Agenda

Background

- 6G Vision
- "AI-Native" Wireless Networks

Developing AI for the Physical Layer

- AI Channel Estimation
- Lab-to-Field Methodology

Implementation and Validation

- ARC-OTA Testbed
- Results

Conclusions and Next Steps

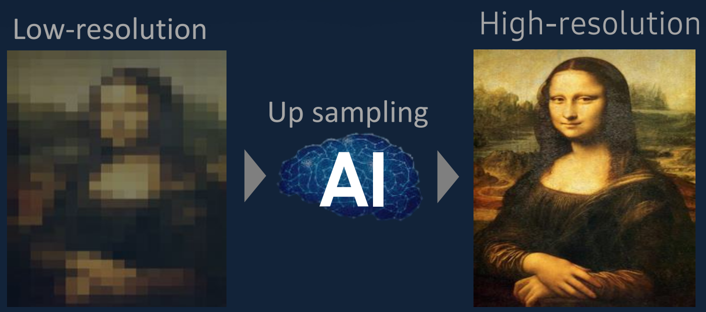
6G Vision

- Differs from 4G/5G’s pursuit of 10x data rate/latency enhancement
- Focus on AI-native wireless, better efficiency and coverage, lower CapEx/OpEx

AI-Native Communication Systems

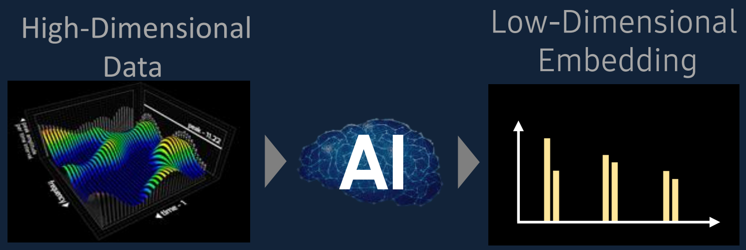
- AI can enhance user experience, lower power consumption, and better performance
- AI is naturally capable of optimizing highly nonlinear and complex systems

Working with Partial Info



Predicts missing info by learning prior distribution

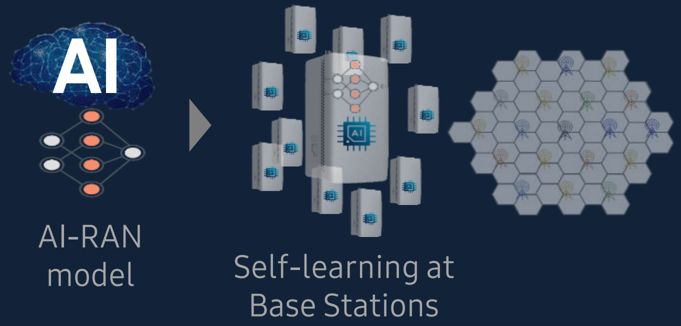
High-Dim. Data Handling



Efficient representation of high-dim. data using low-dim. manifold

Self-Adaptive Learning

A million solutions for a million base stations

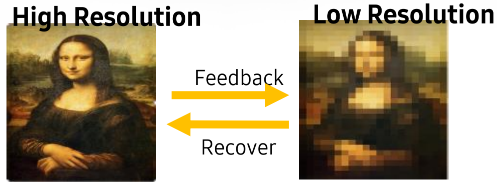


Enables site-specific optimization

AI Applications and Use Cases for 5G/6G

- AI-enhanced, site-specific PHY/MAC
- End-to-end automation

AI for L1/L2 Radio



AI Channel Estimation & Prediction

AI Precoding & Scheduler

AI for Network Automation

Network Analytics

Network Parameter Optimization

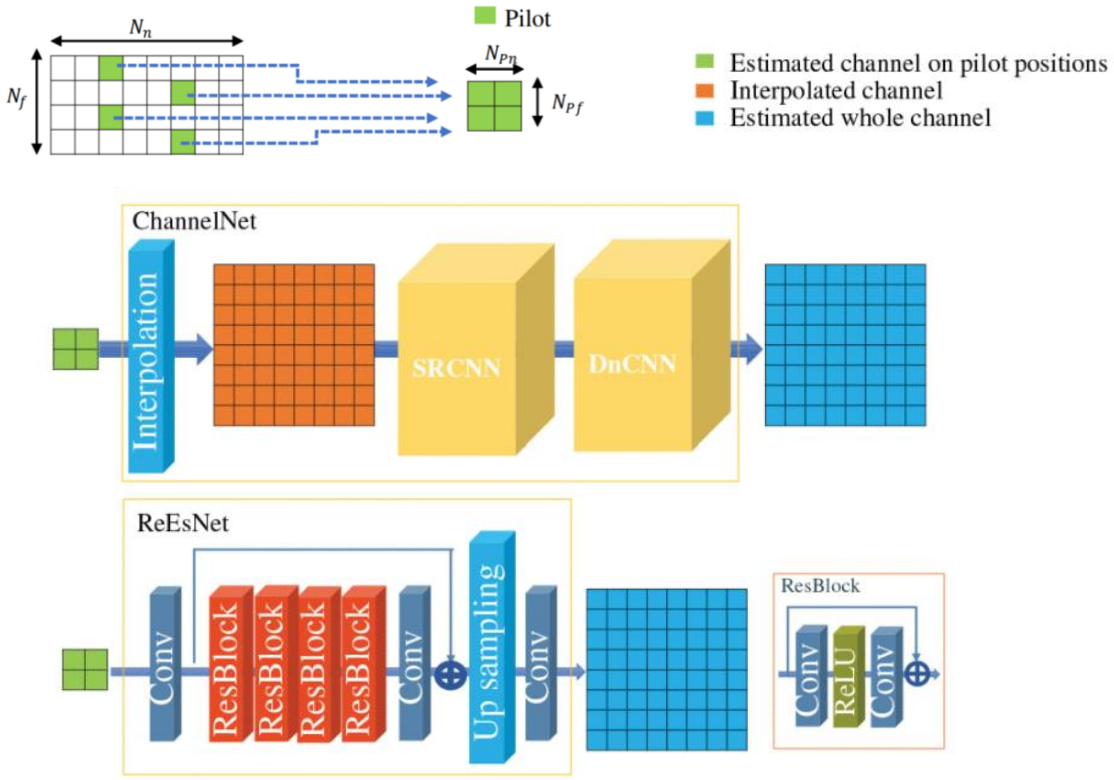
Telco LLM

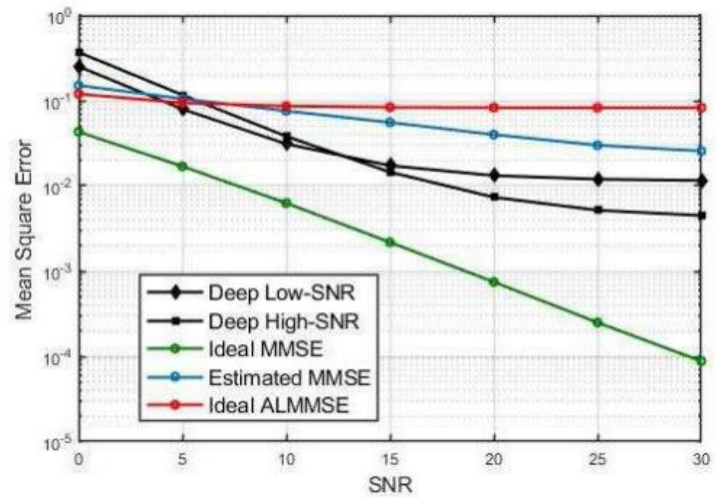
Intent-based Optimization

Multi-tenancy LLM

AI Channel Estimation

- Example: CNN-based OFDM channel estimation*
- Shows gains vs. conventional methods on simulated channels
- Not yet validated in real world





Gains of ChannelNet vs. conventional MMSE**

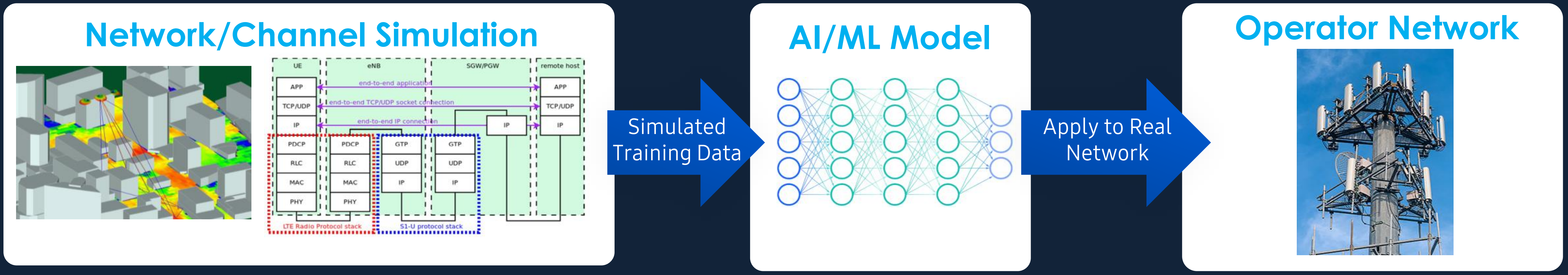
* Li. et al., Deep Residual Learning Meets OFDM Channel Estimation (2020)

** Soltani et al., Deep Learning-Based Channel Estimation (2019)

Challenges for AI RAN

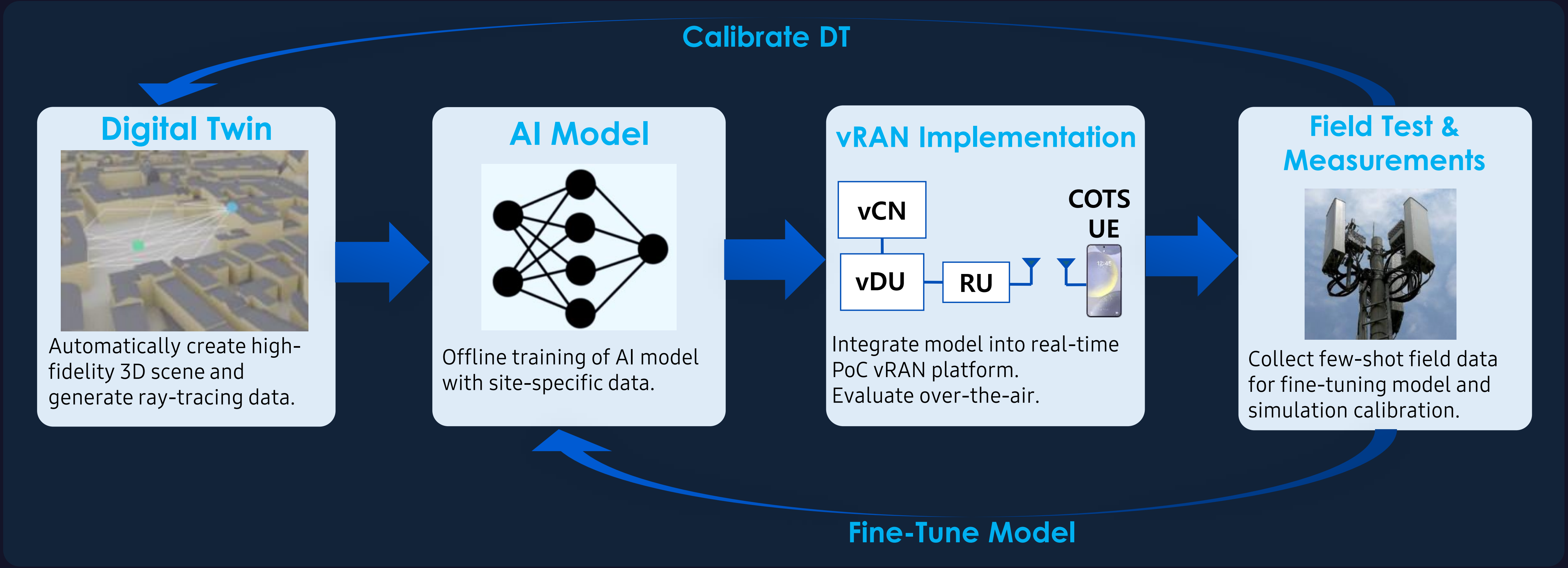
How to train AI models that perform well in real networks?

- Reality gap: Domain shift between simulated and real-world distributions
- Ground truth labels difficult to obtain
- Online training in live network not practical
- High-fidelity simulations have high computation cost
- Balancing complexity vs. performance



Lab-to-Field Approach

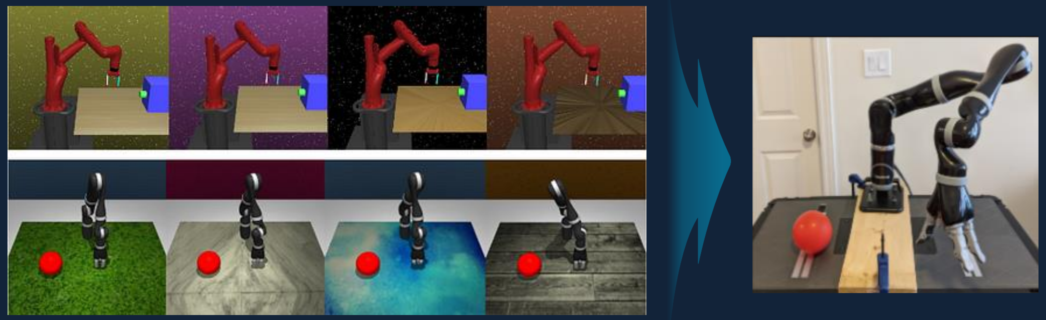
- Combine accurate Digital Twins with limited field data
- Validate with testbed implementation and commercial devices



Channel Data Generation with Sionna

- Statistical channel models: Generate data over range of parameters
- GPU acceleration: Can generate large datasets quickly
- Ray Tracing: Model 3D indoor/outdoor environments
- Domain randomization to introduce random variations → Improve generalizability

Ray Tracing Scenarios

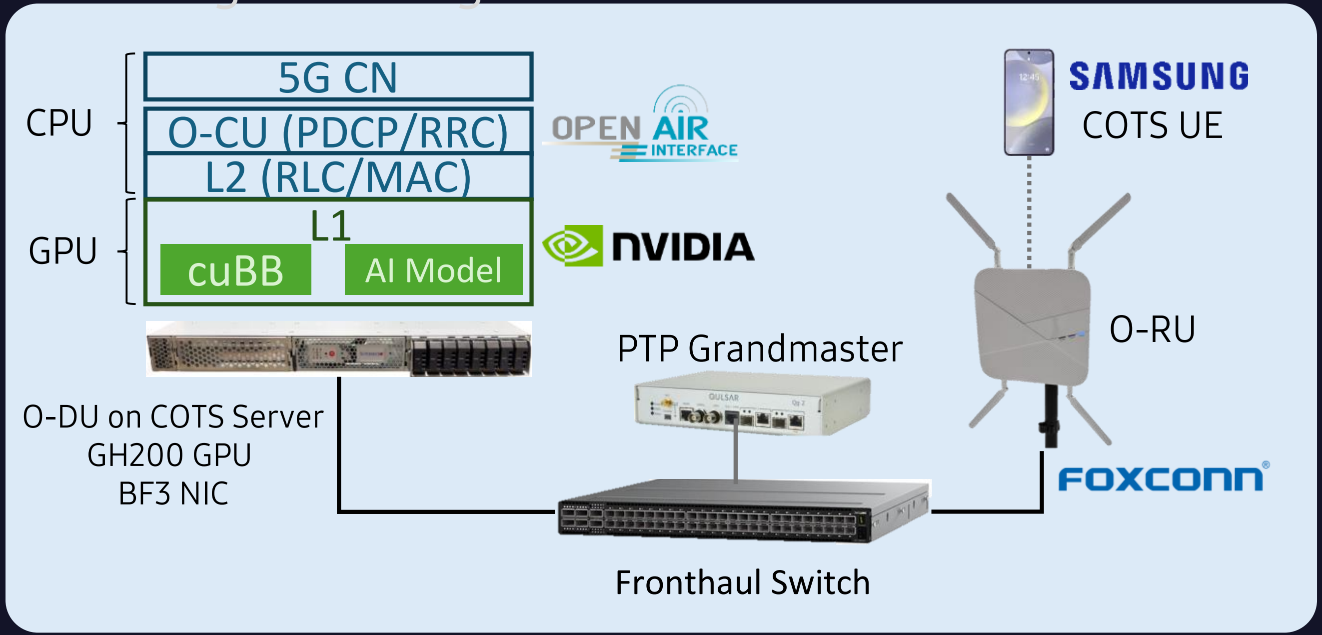


from Mozifan et al., Intervention Design for Effective Sim2Real Transfer (2020)

Domain Randomization

OTA Testbed

- Aerial L1 combined with OAI L2+ offers high degree of flexibility
- Can be modified to implement custom algorithms
- In-line GPU acceleration enables high data rates, massive MIMO
- 3GPP and O-RAN compliant: Compatible with commercial O-RU and Ues
- Significant gain observed.

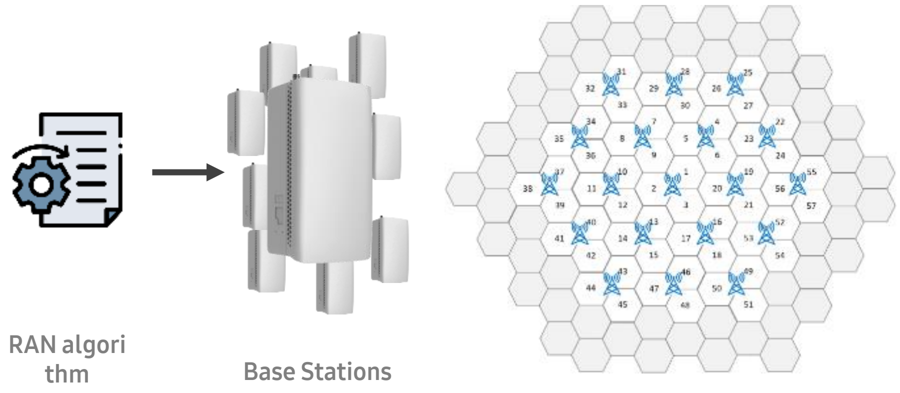


Self-learning B5G/6G network with AI

AI enables customized design for each cell with site-specific optimization

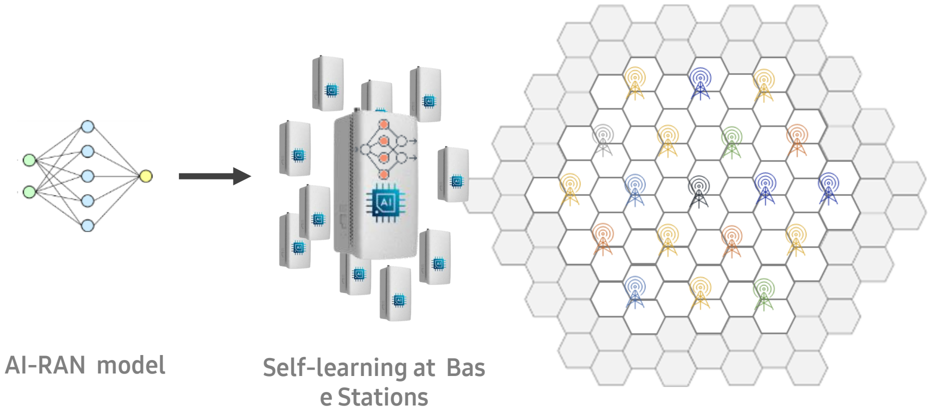
Today

One solution for millions of base stations



Future

A million solutions for a million base stations



Thank You & Questions

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